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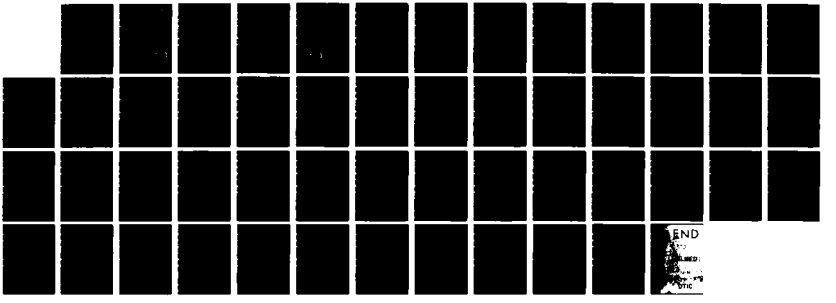

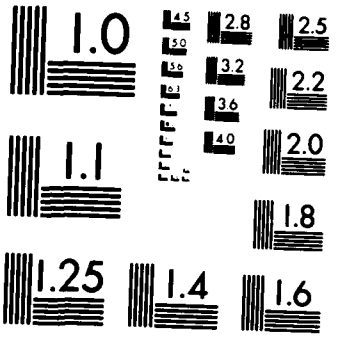

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HELICOPTER NOISE SURVEY PERFORMED AT LAS VEGAS, NEVADA

JANUARY 19-21, 1984

By

Steven R. Albersheim

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16. Abstract

The FAA conducted a noise measurement survey of helicopter operations at Las Vegas during the Annual Helicopter Association International Convention. The survey was performed during the period of January 19-21, 1984. The purpose of this noise survey was to obtain additional noise data for a number of different helicopter models during normal operations in an urban environment. This survey was the first test program which measured sideline noise levels beyond 500 feet. The data collected are classified as survey type data, since the data obtained were from "target of opportunity" as apposed to "controlled test data."

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction

At the present time, the FAA is in the process of examining noise levels associated with helicopter operations. Since helicopters operate at a much lower altitude and slower speed than fixed-wing aircraft, the noise associated with them appear to be more pronounced. The purpose of this study is to obtain additional noise level data of a number of different helicopter types during normal operations in an urban environment..

During the period of January 19-21, 1984, the Helicopter Association Internation (HAI) held their annual convention at Las Vegas, Nevada. Helicopter manufacturers participating in the convention usually have on-hand demonstration helicopters at the flight-line to give rides to potential customers with the purpose being to demonstrate the performance capabilities and features of the helicopter. On the average there are 200-300 operations per day. Because of the high frequency of operations, this affords the FAA the opportunity to take noise measurements for a wide range of helicopter models at one location over a short period of time for representative in-service operations. In addition it provides the opportunity to determine the consistency between $L(max)^{*}$ values for the same helicopter model for different events, but with variations in operations due to changes in speed, glide slope, load, pilots, etc. During this convention

* L(max) refers to the A-weighted sound level, expressed in decibels.

there were 14 models on the flight line.

The noise data collected during the convention are classified as survey type data, since the data obtained were from "targets of opportunity" as opposed to "controlled test data". The helicopter flight corridors into and out of the departure and landing sites were prescirbed by the airport to separate the helicopter operations from the fixed wing. However, there were no limitations placed on the helicopter pilots on individual flight paths, rate of climb, rate of descent, etc.

It should be noted that this test is a continuation of FAA's effort to develop a data base of noise levels associated with helicopter operations in an urban environment, which were conducted at Chicago, Long Beach, New Orleans, New York, Portland, and Seattle. In addition, this was the first test program which measured sideline noise levels beyond 500 feet. This test can be compared to the FAA/HAI Helicopter Flight Operations Noise Test where measurements were made out to 2000 feet for normal operations under "controlled" conditions.

2.0 Noise Measurement Program

The FAA in conjunction with support from Bell Helicopter and Sikorsky Aircraft conducted three separate noise measurement

programs during the convention. The test plan used for the noise monitoring program was developed and implemented by the FAA. Industry participation consisted of providing coordination with helicopter traffic control and noise measurement crews who worked under the guidance of the FAA. With industry's assistance it was possible to deploy a number of noise monitoring stations.

There were two principal noise measurement programs conducted at Las Vegas. The first part of the noise measurement program was conducted at McCarran International Airport at the flight line. The second noise measurment program was conducted at the Las Vegas Convention Center where typical terminal flight operations were measured.

At McCarran the primary aims were to measure centerline and sideline maximum A-weighted noise level, L(max), during arrivals and departures from the flight line. To measure sideline noise levels, noise monitoring stations were located at selected distances out to 1200 feet normal to centerline. Due to the physical constraints, (e.g. approach path and runway alignments) imposed on locating the noise monitoring stations for arrivals, it was only possible to measure sideline noise levels out to 200 feet from the centerline.

The purpose of the noise test at the Convention Center was to obtain a perspective of noise levels from helicopter operations at a representative in-service helipad. The operations consisted of hover-in-ground-effect at different headings and flat-pitch-idle-running.

3.0 Site Description

Las Vegas is located in a desert climate in a valley which runs in a north-south direction. McCarran International Airport is located approximately 4 miles south of the center of the city and is classified as a large hub airport. The HAI flight line was located on the southwest corner of the airport property, at the Hughes Terminal which services charter and general aviation operations. The control tower at the Hughes Terminal is not used on a daily basis, but was activated to coordinate the helicopter operations for the HAI Convention.

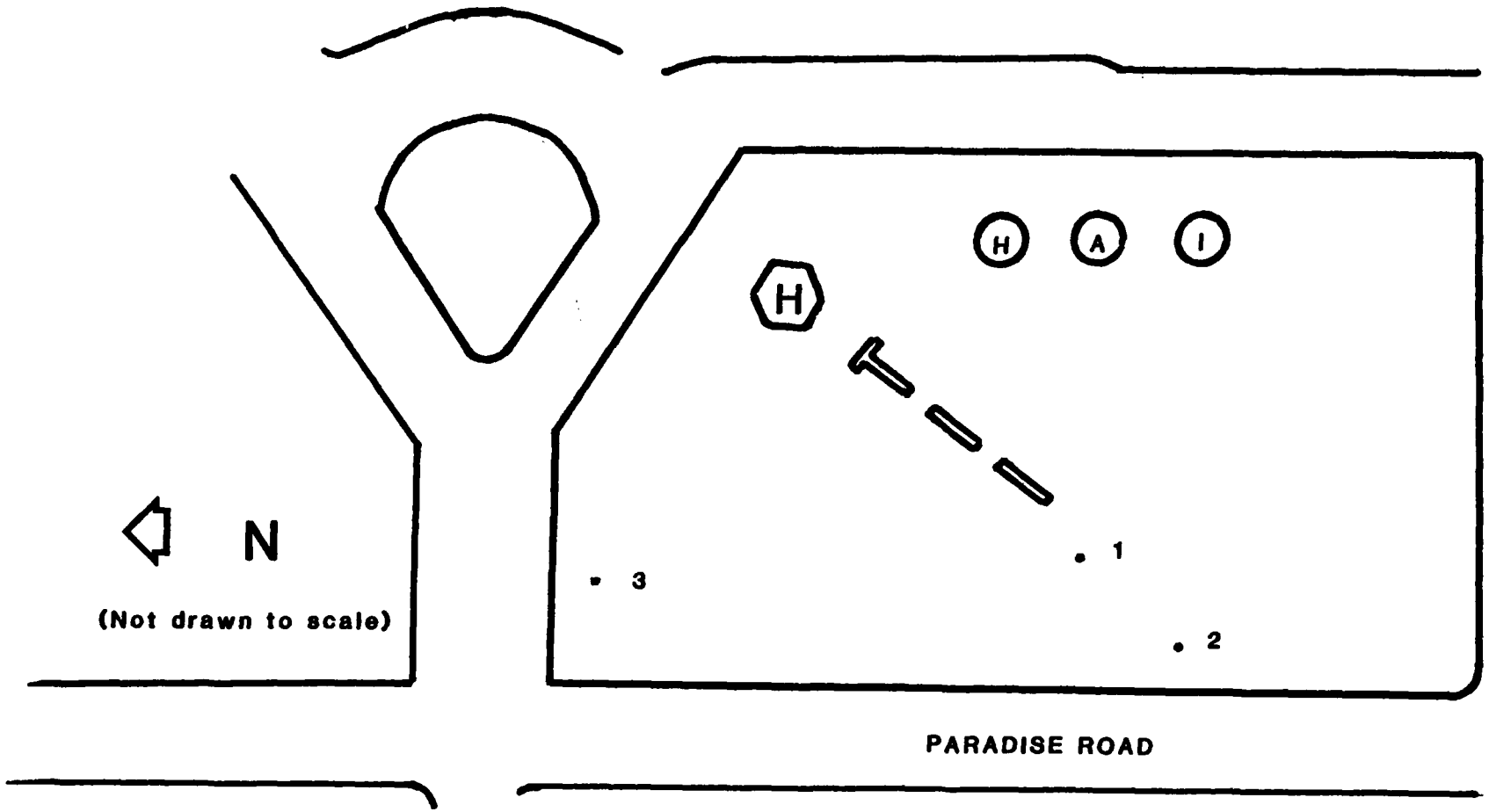
Vegetation around McCarran is sparse due to the arid climate. The ground is principally a rocky substrate. The significance of this with respect to the noise measurement program is that the monitoring sites were always located on an acoustically hard ground surface.

Locations of the noise stations for the monitoring conducted at the Convention Center, and departures and arrivals at McCarran. are described below.

3.1 Convention Center

At the Convention Center, two noise monitors were located on the centerline approach and departure path of the helipad as shown in Figure 1. These sites were designated as 1 and 2 and were 304 and 511 feet, respectively from the center of the helipad. Site 3 was located at 270° off the center of the helipad at a distance of 294 feet. This placed the site at a 90° angle to the centerline in order to provide some measure of directivity of the sound to the sideline. Ideally, an array of microphones surrounding the helipad would be used to measure the directivity of noise with respect to approach, departure, and routine terminal operations. Due to the limitation of personnel and equipment it was not feasible to establish such a sophisticated array. The fourth site was located at 33° off the centerline (i.e. toward the southwest at a distance of 775 feet from the center of the helipad. This site was to measure sideline noise levels during approach and departure.

FIGURE 1 NOISE MONITORING STATIONS AT THE CONVENTION CENTER



All of the sites were exposed to a high level of ambient noise due to their proximity to Paradise Rd., which is a 6-lane highway running in a north-south direction parallel to the Convention Center. During the noise monitoring, traffic was consistently heavy with the majority of the vehicles passing by being automobiles interspersed with bus and heavy duty trucks. Site 4 which was the fartherest from the helipad was effected the most by the traffic. There were times during the test when noise levels from the helicopter did not exceed the ambient at site 4.

3.2 McCarran

Figure 2 shows the respective locations of the noise monitoring stations for departures. Sites 1 and 2 for departures were located at a distance of 1325 and 1525 feet on the centerline from the helipad. Sites 3, 4, 5, and 6 were located at a distance of 600, 800, 1000, and 1200 feet normal to site 1 to the south of the departure path. Site 1 was designated as the primary site. All of the sites were situated on a rocky/sandy surface and were located at a distance of 900 feet from Las Vegas Blvd. Hence, traffic did not interfere with the signal to noise ratio from the helicopters.

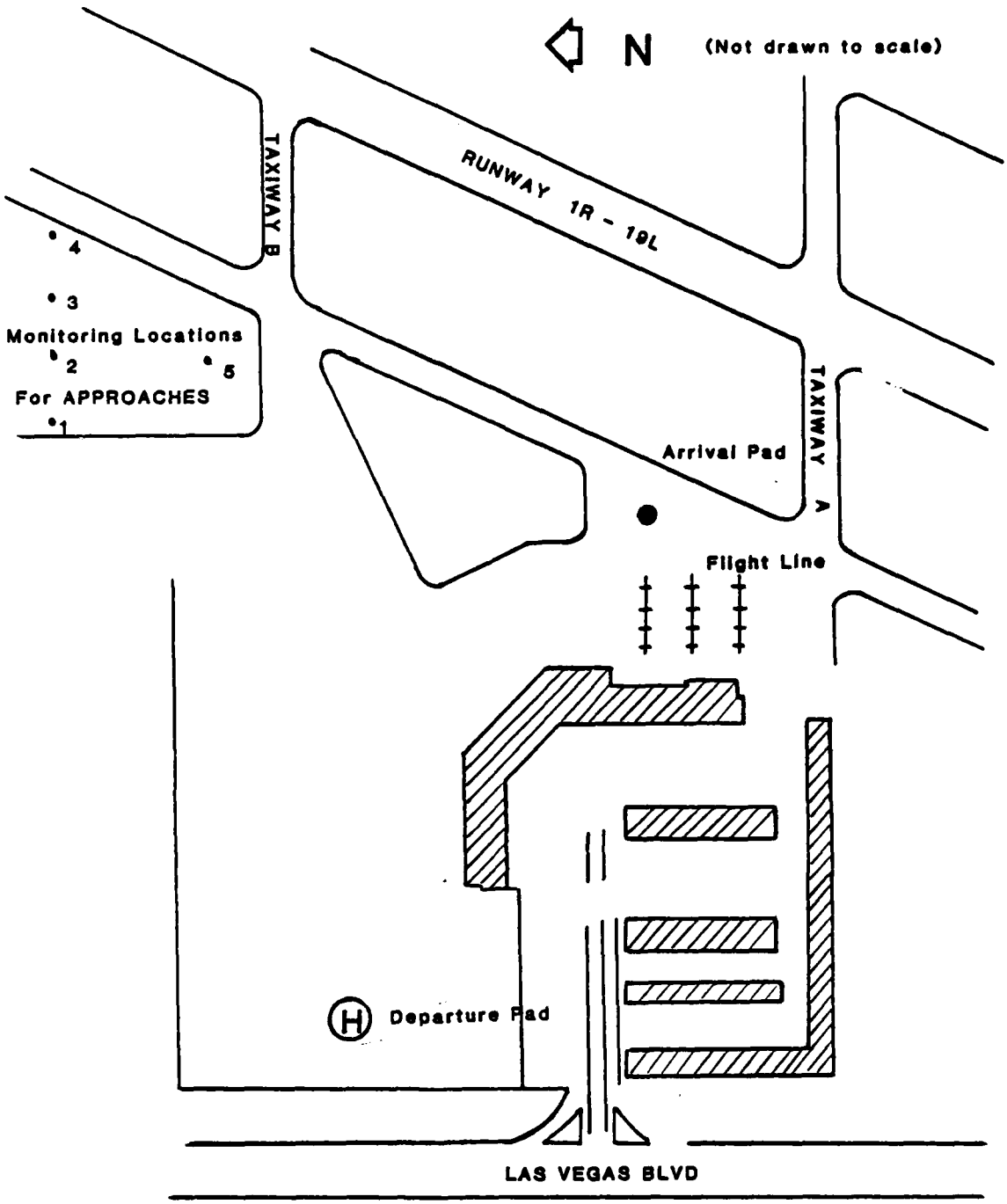


FIGURE 2 NOISE MONITORING STATIONS AT McCARRAN NTERNATIONAL AIRPORT

Sites 4, 5, and 6 were closest to runway 07-25 which was the principal runway in use on January 19, 1984 for air carrier departures. Airlines departed predominantly to the west. As a result, many of the helicopter noise events were contaminated with jet noise. Data presented for these sites were screened and only those noise levels clearly set by the helicopter are reported.

It was not possible to use the same noise monitoring locations and array to monitor the noise levels for arrivals since the approach path was from the north for arrivals and departures were to the west. The only practical location to monitor noise for arrivals was to locate the noise stations between runway 01R-19L and the taxiway as shown in Figure 2. Because of the navigation restrictions at the airport for helicopter approaches, this was the only location available where the helicopters would be 200-300 feet directly overhead the centerline microphone. It was not feasible to set-up an array extending out to 1200 feet from the centerline as was done for departures. Site 4 which was the fartherest station from the centerline was 200 feet to the east along the normal. Site 5 was on the centerline 200 feet to the south of the primary site. As in the departures, all the sites

were located on a rocky/sandy surface. There was occasional interference from taxing aircraft resulting in a lost of some of the observations. Other events were lost as a result of the helicopter not flying over the centerline positions.

4.0 Meteorological Conditions

Weather conditions were quite suitable during the noise monitoring program of January 19-21, 1984. The surface temperature as measured by the National Weather Service at the airport ranged from 40 to 50F during the three day test period. On the 19th and 20th, the winds were principally from the north averaging 5 to 7 knots. On the 21st, the wind direction shifted to the south with an average speed of 5 to 9 knots with overcast conditions for much of the day. Relative humidity ranged from 19 to 50% during the test. The noise data presented in this report have not been adjusted for meteorological conditions.

5.0 Instrumentation

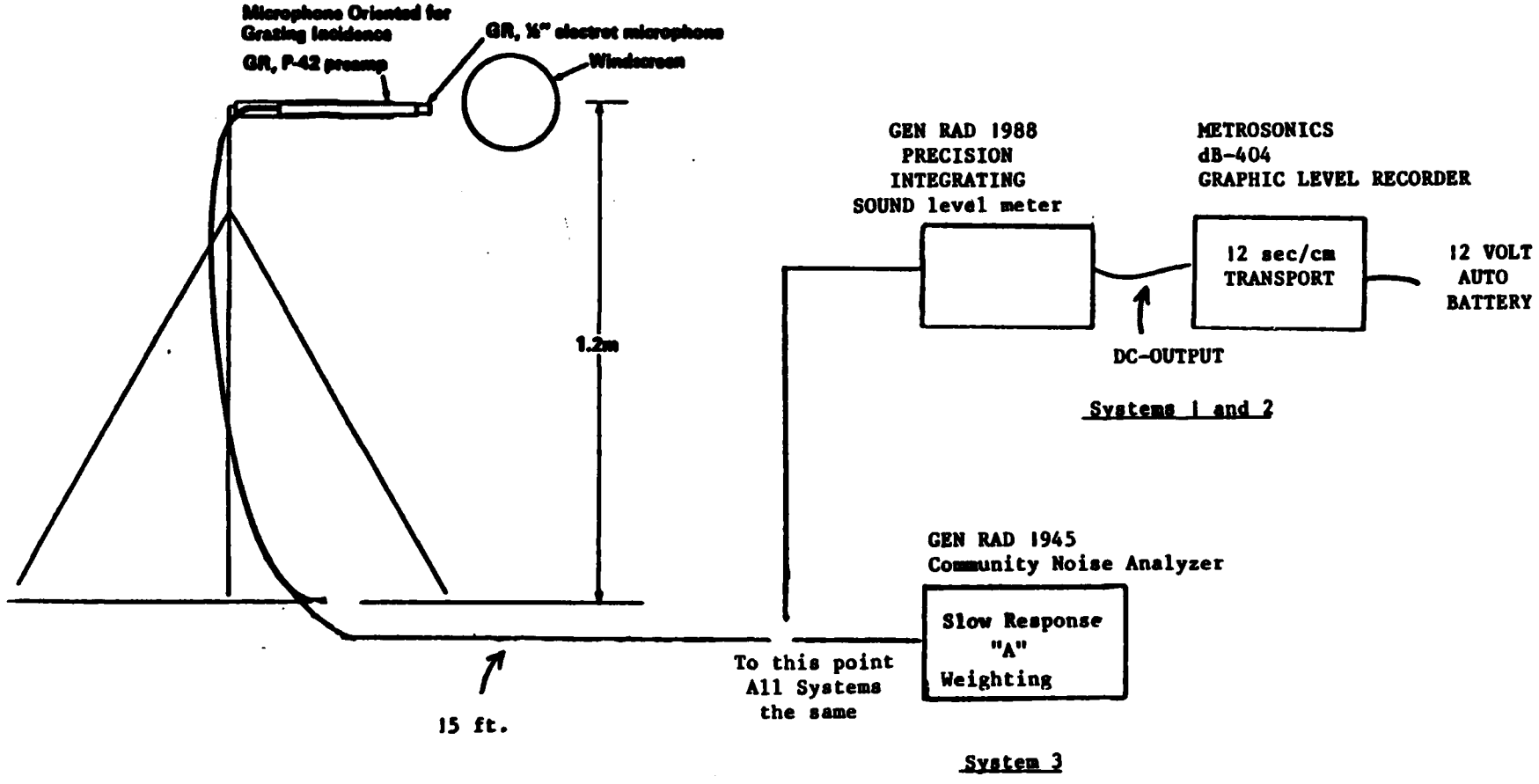
A schematic of the acoustic measurement system is shown in Figure 3 for a typical configuration of equipment used. The following equipment was used at different times during the noise monitoring program: Gen Rad 1988's Precision Integrating Sound Level Meter (ISLM), B&K Model 2218 Precision Integrating Sound Level Meter (ISLM), and NAGRA SVJ tape recorder.

Each Gen Rad 1988 ISLM used a P-42 microphone-preamplifier driving a Gen Rad 1/2 inch electret microphone. The microphone-preamplifier assembly was mounted on a tripod four (4) feet above ground level with the diaphragm oriented for grazing incidence. The analog signal was recorded as a hard copy through direct read out to a graphic level recorder and at the same time was converted to a digital output.

The B&K system used a 1/4 inch condenser microphone. The system is self contained in that the microphone was directly attached to the ISLM. Output was observed on an analog scale and digital read out on the ISLM. There was no hard copy made of the analog signal.

At the end of each event, the observer using either system noted

FIGURE 3 **ACOUSTICAL MEASUREMENT INSTRUMENTATION**



in a log the digital read out of the L(max), Leq, SEL*, and the duration of the event.

All the microphones were located at distances of 20-30 feet from the observer to avoid any interference with the signal to noise ratio.

The NAGRA SVJ recorder analog signal was amplified to a suitable recording level and was recorded on channel one. A time code was recorded on channel two for traceability of events. Channel two was used to orally annotate the tape by the observer. The magnetic tapes were later reduced and analyzed in a laboratory.

6.0 Disucssion of the Data

6.1 McCarran Departures

Noise levels associated with departures were monitored on January 19, 1984, at McCarran International Airport. During the monitoring period there were 89 events which was comprised of 14 different helicopter models. Table 1 provides a listing of the

* Leq refers to equivalent sound energy and SEL is the sound exposure level integration of the L(max) time history, normalized to 1 second

TABLE 1 **Helicopter Noise Levels Measured At McCarran During Departures For All Events**

(Altitude, Slant Range, Lmax)

January 18, 1984

Event Number	Helicopter	Altitude Centerline (ft)	Slant Range for Noise Monitoring Stations (ft)				Lmax (dBA) Station Locations					
							1	2	3	4	5	6
0	Bell 206-L	353	696	874	1060	1251	77.4	77.5	74.1		68.9	66.0
1	Bell 206-B	NA	NA	NA	NA	NA	77.8	79.8	73.8	72.5		68.0
2	BK-117	NA	NA	NA	NA	NA	67.3	69.7	66.4	65.5		61.0
3	A-STAR	163	622	816	1013	1211	81.1	87.0	72.7	70.0	66.5	65.0
4	Enstrom 280 FX	NA	NA	NA	NA	NA	80.3	81.4		74.0		72.0
5	Agusta 109A	NA	NA	NA	NA	NA		89.6	80.9		74.2	72.0
6	Twin Star	188	629	822	1018	1215	84.1	85.2				67.0
7	Hughes 530F	NA	NA	NA	NA	NA	80.6	82.0				67.0
8	Hughes 500E	NA	NA	NA	NA	NA	80.9	97.7			72.7	71.0
9	BK-117	176	625	819	1015	1213	84.0	84.4				70.0
10	Agusta 109A	230	643	832	1026	1222	85.8	87.6	80.0		73.7	71.0
11	Hughes 500E	220	639	830	1024	1220	81.5	82.5	71.2	68.0	63.7	61.2
12	BK-117	181	627	820	1016	1214	83.1	82.5	71.6	69.7	66.0	65.0
13	Bell 206-L	197	632	824	1019	1216	82.9	82.4	74.0	72.7		66.0
14	Hughes 500E	240	646	835	1028	1224	82.7	86.6				
15	Hughes 530F	351	695	874	1060	1250	83.2	82.6		71.8	68.4	65.0
16	Enstrom 280 FX		NA	NA	NA	NA	80.2	78.8	78.0	68.9	68.0	
17	Dauphin		NA	NA	NA	NA	87.6	86.3	75.4	73.4	69.8	70.0
18	Bell 222		NA	NA	NA	NA	79.5	79.7	76.7	76.2	72.4	70.0
19	BO-105	438	743	912	1092	1277	80.8	79.5	70.6	68.0	65.6	65.0
20	Hughes 500E	276	660	846	*1037*	*1231*	80.0	79.0	71.3	69.1	64.4	63.0
21	Hughes 500D		NA	NA	NA	NA	74.3	74.6	70.2	68.5	64.5	64.0
22	Bell 206-B	158	620	815	1012	1210	84.0	82.6	71.8	69.7		68.0
23	Hughes 500C	364	702	879	1064	1254	82.2	82.8	75.5	73.4	71.6	71.0
24	Bell 206-L	264	656	842	1034	1229	81.1	80.1	72.4	73.4	66.2	69.0
25	Dauphin		NA	NA	NA	NA	83.9	84.1	76.9	74.3	69.2	70.0
26	Hughes 500E	216	638	829	1023	1219		83.5				
27	Bell 222	260	654	841	1033	1228	81.3	86.6				
28	BK-117	218	638	829	1023	1220	83.3	80.4	72.2	73.0	69.1	68.0
29	Enstrom 280 FX	286	665	850	1040	1234	82.2	81.5	72.0	69.2		68.0
30	BO-105	296	669	853	1043	1236		82.5				
31	Enstrom 280 F	282	663	848	1039	1233	79.4	78.7	74.0	73.1	69.3	70.0
32	Agusta 109A		NA	NA	NA	NA	82.4	80.4	75.5	73.1		
33	Hughes 500E	272	659	845	1036	1230	80.3	80.2	71.9	71.1	66.3	67.0
34	Dauphin	216	638	829	1023	1219	84.8	84.4	76.4	74.1	69.0	70.0
35	Hughes 500D	295	669	853	1043	1236		89.2				
36	*Hughes 530F*	*311*	*674*	*858*	*1047*	*1240*	79.9	79.0	73.1	70.8	67.8	65.0
37	Twin Star		NA	NA	NA	NA	79.9	77.9	70.5	69.3	65.6	67.0
38	Enstrom 280-FX		NA	NA	NA	NA	80.2	79.9	70.4	68.0	65.0	65.0
39	BK-117		NA	NA	NA	NA	82.3	81.0				
40	Bell 222	292	647	852	1042	1235	84.1	83.6	73.8			71.0
41	BO-105	183	627	821	1017	1214	84.1	83.4	74.2	73.8	69.0	67.0
42	Dauphin	164	622	817	1013	1211	89.4	90.3	75.8	73.5	69.9	68.0
43	*Hughes 500D*	298	670	854	1043	1236	80.8	81.2		72.0		67.0
44	Bell 206-B		NA	NA	NA	NA	76.4	73.5	67.4	65.0		61.0
45	Agusta 109A		NA	NA	NA	NA	85.1	83.0	75.3	74.5	70.5	71.0
46	Hughes 500E	280	662	848	1038	1232	79.7	78.5	71.2	69.7	65.8	64.0
47	A-STAR	208	635	827	1021	1218	82.2	80.9	69.9	68.0		62.0
48	Twin Star	376	708	884	1068	1258	80.3	80.5	71.4	70.1	64.0	65.0
49	Bell 222	312	676	859	1048	1240	84.6	83.4	73.6	74.2		

TABLE 1 (Cont')

Event Number	Helicopter	Altitude Centerline (ft)	Slant Range for Noise Monitoring Stations (ft)				Lmax (dBA) Station Locations					
							1	2	3	4	5	6
50	Enstrom 280-FX		NA	NA	NA	NA	77.2	77.1	71.0	68.9		63.0
51	Hughes 500D	299	670	854	1044	1237	81.4	81.9	74.4	72.1	68.0	67.0
52	Bell 206-B	284	664	849	1040	1233	79.0	79.3	71.8	70.9	67.0	65.0
53	Bell 412	259	654	841	1033	1228	87.7	89.2	78.7	78.7	75.0	72.0
54	Hughes 500E	204	634	826	1021	1217	82.2		72.1	71.0	65.0	64.0
55	Bell 206-L	206	634	826	1021	1218	81.7	80.8	72.9	72.0		
56	Enstrom 280-FX		NA	NA	NA	NA		80.3	71.3	69.0		69.0
57	BK-117		NA	NA	NA	NA		76.8		69.0		
58	Dauphin		NA	NA	NA	NA	84.0	85.0	74.3	73.1	68.0	67.0
59	Agusta 109A		NA	NA	NA	NA	87.2	86.4	76.9	77.2	72.4	71.0
60	A-STAR		NA	NA	NA	NA	82.9	81.8	69.9	69.0	63.0	63.0
61	Hughes 500E		NA	NA	NA	NA	71.0			65.1	61.0	62.0
62	Bell 206-L		NA	NA	NA	NA	74.2	74.7		67.5	64.0	64.0
63	Hughes 500D	361	700	878	1063	1253	79.5	78.9		72.0	69.0	66.0
64	Twin Star	444	758	925	1102	1287	79.7	79.2	70.5	69.0	67.0	65.0
65	Bell 206-B	174	625	819	1015	1213		89.1				
66	Hughes 530F	276	660	846	1037	1231	82.2	78.2			71.0	
67	BK-117	301	671	855	1044	1237	79.9	78.4		72.7		67.0
68	Enstrom 280-FX		NA	NA	NA	NA	78.6	79.7		71.0		
69	Bell 206-L	403	723	896	1078	1266		78.7		74.0		66.0
70	Bell 47	195	631	823	1019	1216	78.0	78.7		67.7	66.0	63.0
71	A-STAR	203	633	825	1020	1217	80.5	80.8		70.0		67.0
72	Bell 206-B	262	655	842	1034	1228	80.1	80.1	63.3	69.4	66.8	
73	Hughes 500E	246	648	837	1030	1225	80.5	80.3	64.2	70.3	67.5	65.0
74	Enstrom 280-FX		NA	NA	NA	NA	79.5	78.6		74.5		
75	Twin Star	179	626	820	1016	1213	83.4	81.8	64.6	72.6	68.3	65.0
76	Hughes 530F	262	655	842	1034	1228	83.9	83.4		76.6		65.0
77	BO-105	431	739	909	1089	1275	81.1	79.1	66.5	74.5	68.6	67.0
78	Dauphin	208	635	827	1021	1218	85.6	85.9				
79	Bell 206-L	264	656	842	1034	1229	80.4	80.8		73.0	70.0	67.0
80	Bell 222		NA	NA	NA	NA	89.4	88.1				
81	Bell 206-B	257	653	840	1032	1227	81.8	80.4		69.8	67.3	63.0
82	Agusta 109A		NA	NA	NA	NA	81.7	79.4			69.9	65.0
83	Hughes 500E	214.00	637	828	1023	1219	82.2	81.5			66.5	65.0
84	Enstrom 28F		NA	NA	NA	NA	80.4	77.1			66.0	64.0
85	BK-117	348.00	694	872	1059	1249	79.7	78.8			67.0	66.0
86	Twin Star	303.00	672	855	1045	1238	80.8	79.4				66.0
87	A-Star	363.00	701	879	1064	1254	78.4	79.2			69.0	66.0
88	Enstrom 280-FX		NA	NA	NA	NA	81.6	81.4			66.0	67.0

NOTE Site 1 is the primary centerline site 1325 ft. from the helipad
Site 2 is on the centerline 1525 ft. from the helipad
Site 3 is a sideline site 600 ft. south of site 1
Site 4 is a sideline site 800 ft. south of site 1
Site 5 is a sideline site 1000 ft. south of site 1
Site 6 is a sideline site 1200 ft. south of site 1

Blanks are lost data due equipment malfunction, contamination, etc.

helicopters measured by their event of occurrence. In addition, Table 1 provides the altitude of the helicopter as it passed over the centerline position and associated slant ranges for the other monitoring sites and the L(max) in dB(A) as recorded for each position. Table 1a is a continuation of the information obtained during departures which lists the L(max), elevation angle, and the difference between the L(max) for centerline and the sideline sites.

Review of the data as presented in Tables 1 and 1a reveal that there were many events in which the L(max) values were not measured at several sites or there was no determination of altitude and subsequently slant range was not available. The primary cause for lost of events was the result of contamination from air carrier jet departures westbound from runway 07-25. Site locations 4, 5, and 6 were the principle sites effected as a result of air carrier operations. At site 3 there was a complete failure of the noise monitoring equipment beginning at event 78 resulting in a lost of L(max) values at this site for events 78 through 88.

Additional events were lost due to the helicopter's not flying over

TABLE 1a **Helicopter Noise Levels Measured At McCarran During Departures For All Events**

(Lmax, Elevation Angle , Delta Lmax)

January 19, 1984

Event Number	Helicopter	Lmax (dBA) Station Locations						Elevation Angle (Degrees) Station Locations				Difference between Centerline and Sideline Sites (dBA)			
		1	2	3	4	5	6	3	4	5	6	1-3	1-4	1-5	1-6
0	Bell 206-L	77.6	77.5	74.1		68.9	66.0	30.47	23.81	19.44	16.39	3.50	NA	8.70	11.60
1	Bell 206-B	77.8	79.8	73.8	72.5		68.0	NA	NA	NA	NA	4.00	5.30	NA	9.80
2	BK-117	67.3	69.7	66.4	65.5		61.0	NA	NA	NA	NA	0.90	1.80	NA	6.30
3	A-STAR	81.1	87.0	72.7	70.0	66.5	65.0	15.20	11.52	9.24	7.74	8.40	11.10	14.60	16.10
4	Enstrom 280 FX	80.3	81.4		74.0		72.0	NA	NA	NA	NA	NA	6.30	NA	8.30
5	Agusta 109A		89.4	80.9		74.2	72.0	NA	NA	NA	NA	NA	NA	NA	NA
6	Twin Star	84.1	85.2				67.0	17.40	13.22	10.65	8.90	NA	NA	NA	17.10
7	Hughes 530F	80.6	82.0				67.0	NA	NA	NA	NA	NA	NA	NA	13.60
8	Hughes 500E	80.9	97.7			72.7	71.0	NA	NA	NA	NA	NA	NA	8.20	9.90
9	BK-117	84.0	84.4				70.0	16.35	12.41	9.98	8.34	NA	NA	NA	14.00
10	Agusta 109A	85.8	87.6	80.0		73.7	71.0	20.97	16.04	12.95	10.85	5.80	NA	12.10	14.80
11	Hughes 500E	81.5	82.5	71.2	68.0	63.7	61.2	20.14	15.38	12.41	10.39	10.30	13.50	17.80	20.30
12	BK-117	83.1	82.5	71.6	69.7	66.0	65.0	16.79	12.75	10.26	8.58	11.50	13.40	17.10	18.10
13	Bell 206-L	82.9	82.4	74.0	72.7		66.0	18.18	13.83	11.14	9.32	8.90	10.20	NA	16.90
14	Hughes 500E	82.7	86.6					21.80	16.70	13.50	11.31	NA	NA	NA	NA
15	Hughes 530F	83.2	82.6		71.8	68.4	65.0	30.33	23.69	19.34	16.38	NA	11.40	14.80	18.20
16	*Enstrom 280 FX*	*80.2*	*78.8*	*78.0*	*68.9*	*68.0*		NA	NA	NA	NA	2.20	11.30	12.20	NA
17	Dauphin	87.6	86.3	75.4	73.4	69.8	70.0	NA	NA	NA	NA	12.20	14.20	17.80	17.40
18	Bell 222	79.5	79.7	74.7	74.3	72.4	70.0	NA	NA	NA	NA	2.80	3.30	7.10	9.50
19	BO-105	80.8	79.5	70.6	68.0	65.6	65.0	36.13	28.70	23.65	20.05	10.20	12.80	15.20	15.80
20	Hughes 500E	80.0	79.0	71.3	69.1	64.4	63.0	24.70	19.63	15.43	12.95	8.70	10.90	15.60	17.00
21	Hughes 500D	76.3	74.6	70.2	68.5	64.5	64.0	NA	NA	NA	NA	6.10	7.80	11.80	12.30
22	Bell 206-B	84.0	82.6	71.8	69.7		68.0	14.75	11.17	8.98	7.50	12.20	14.30	NA	16.00
23	Hughes 500C	82.2	82.8	75.5	73.4	71.4	71.0	31.24	24.47	20.00	16.87	6.70	8.80	10.60	11.20
24	Bell 206-L	81.1	80.1	72.4	73.4	66.2	69.0	23.75	18.24	14.79	12.41	8.70	7.70	14.90	12.10
25	Dauphin	83.9	84.1	76.9	74.3	69.2	70.0	NA	NA	NA	NA	7.00	9.60	14.70	13.90
26	Hughes 500E		83.5					19.80	15.11	12.19	10.28	NA	NA	NA	NA
27	Bell 222	81.3	84.6					23.43	18.00	14.57	12.23	NA	NA	NA	NA
28	BK-117	83.3	80.4	72.2	73.0	69.1	68.0	19.97	15.24	12.30	10.30	11.10	10.30	14.20	15.30
29	Enstrom 280 FX	82.2	81.5	72.0	69.2		68.0	25.49	19.67	15.96	13.41	10.20	13.00	NA	14.20
30	BO-105		82.5					26.26	20.30	16.49	13.86	NA	NA	NA	NA
31	Enstrom 280 F	79.6	78.7	74.0	73.1	69.3	70.0	25.17	19.42	15.75	13.22	3.40	6.50	10.30	9.40
32	Agusta 109A	82.4	80.4	75.5	73.1			NA	NA	NA	NA	6.90	9.30	NA	NA
33	Hughes 500E	80.3	80.2	71.9	71.1	66.3	67.0	24.39	18.78	15.22	12.77	8.40	9.20	14.00	13.30
34	Dauphin	84.8	84.4	76.4	74.1	69.8	70.0	19.80	15.11	12.19	10.20	8.40	10.70	15.60	14.80
35	Hughes 500D		89.2					26.18	20.24	16.44	13.81	NA	NA	NA	NA
36	Hughes 530F	79.9	79.0	73.1	70.8	67.8	65.0	27.40	21.24	17.28	14.53	6.80	9.10	12.10	14.90
37	Twin Star	79.9	77.9	70.5	69.3	65.6	67.0	NA	NA	NA	NA	9.40	10.60	14.30	12.90
38	Enstrom 280-FX	80.2	79.9	70.4	68.0	65.0	65.0	NA	NA	NA	NA	9.80	12.20	15.20	15.20
39	BK-117	82.3	81.0					NA	NA	NA	NA	NA	NA	NA	NA
40	Bell 222	84.1	83.6	73.8			71.0	25.95	20.05	16.28	13.68	10.30	NA	NA	13.10
41	BO-105	84.1	83.4	74.2	73.8	69.0	67.0	16.96	12.88	10.37	8.67	9.90	10.30	15.10	17.10
42	Dauphin	89.4	90.3	75.8	73.5	69.9	68.0	15.29	11.59	9.31	7.78	13.60	15.90	19.50	21.40
43	Hughes 500D	80.8	81.2		72.0		67.0	26.41	20.43	16.59	13.95	NA	8.80	NA	13.80
44	Bell 206-B	76.4	73.5	67.4	65.0		61.0	NA	NA	NA	NA	9.00	11.40	NA	15.40
45	Agusta 109A	85.1	83.0	75.3	74.5	70.5	71.0	NA	NA	NA	NA	9.80	10.40	14.40	14.10
46	Hughes 500E	79.7	78.5	71.2	69.7	65.8	64.0	25.02	19.29	15.64	13.13	8.50	10.00	13.90	15.70
47	A-STAR	82.2	80.9	69.9	68.0		62.0	19.12	14.57	11.75	9.83	12.30	14.20	NA	20.20
48	Twin Star	80.3	80.5	71.4	70.1	64.0	65.0	32.07	25.17	20.41	17.40	8.90	10.20	14.30	15.30
49	Bell 222	84.6	83.4	73.6	74.2			27.47	21.31	17.33	14.57	11.00	10.40	NA	NA

TABLE 1a (Cont')

Event Number	Helicopter	Lmax (dBA) Station Locations 1	2	3	4	5	6	Elevation Angle (Degrees) Station Locations 3	4	5	6	Difference between Centerline and Sideline Sites (dBA) 1-3	1-4	1-5	1-6
50	Enstrom 280-FX	77.2	77.1	71.0	68.9		63.0	NA	NA	NA	NA	6.20	8.30	NA	14.20
51	Hughes 500D	81.4	81.9	74.4	72.1	68.0	67.0	26.49	20.49	16.65	13.99	7.00	9.30	13.40	14.40
52	Bell 206-B	79.0	79.3	71.8	70.9	67.0	65.0	25.33	19.54	15.85	13.32	7.20	8.10	12.00	14.00
53	Bell 412	87.7	89.2	78.7	78.7	75.0	72.0	23.35	17.94	14.52	12.18	9.60	9.00	12.70	15.70
54	Hughes 500E	82.2		72.1	71.0	65.0	64.0	18.78	14.31	11.53	9.65	10.10	11.20	17.20	18.20
55	Bell 206-L	81.7	80.8	72.9	72.0			18.95	14.44	11.64	9.74	8.80	9.70	NA	NA
56	Enstrom 280-FX		80.3	71.3	69.0		69.0	NA	NA	NA	NA	NA	NA	NA	NA
57	BK-117		76.8		67.0			NA	NA	NA	NA	NA	NA	NA	NA
58	Dauphin	84.0	85.6	74.3	73.1	68.0	67.0	NA	NA	NA	NA	9.70	10.90	14.00	17.00
59	Agusta 109A	87.2	86.4	76.9	77.2	72.4	71.0	NA	NA	NA	NA	10.30	10.00	14.80	16.20
60	A-STAR	82.9	81.8	69.9	69.0	63.0	63.0	NA	NA	NA	NA	13.00	13.90	19.90	19.90
61	Hughes 500E	71.0			65.1	61.0	62.0	NA	NA	NA	NA	NA	5.90	10.00	9.00
62	Bell 206-L	76.2	74.7		67.5	64.0	64.0	NA	NA	NA	NA	NA	8.70	12.20	12.20
63	Hughes 500D	79.5	78.9		72.0	69.0	66.0	31.03	24.29	19.85	16.74	NA	7.50	10.50	13.50
64	Twin Star	79.7	79.2	70.5	69.0	67.0	65.0	37.72	30.11	24.89	21.14	9.20	10.70	12.70	14.70
65	Bell 206-B		89.1					16.17	12.27	9.87	8.25	NA	NA	NA	NA
66	Hughes 530F	82.2	78.2			71.0		24.70	19.03	15.43	12.95	NA	NA	11.20	NA
67	BK-117	79.9	78.6		72.7		67.0	26.64	20.62	16.75	14.08	NA	7.20	NA	12.90
68	Enstrom 280-FX	78.6	79.7		71.0			NA	NA	NA	NA	NA	7.60	NA	NA
69	Bell 206-L		78.7		74.0		66.0	33.89	26.74	21.95	18.56	NA	NA	NA	NA
70	Bell 47	78.0	78.7		67.7	64.0	63.0	18.00	13.70	11.03	9.23	NA	10.30	12.00	15.00
71	A-STAR	80.5	80.8		70.0		67.0	18.69	14.24	11.48	9.60	NA	10.50	NA	13.50
72	Bell 206-B	80.1	80.1	63.3	69.6	66.8		23.59	18.13	14.68	12.32	16.80	10.50	13.30	NA
73	Hughes 500E	80.5	80.3	64.2	70.3	67.5	65.0	22.29	17.09	13.82	11.59	16.30	10.20	13.00	15.50
74	Enstrom 280-FX	79.5	78.6		74.5			NA	NA	NA	NA	NA	5.00	NA	NA
75	Twin Star	83.4	81.8	64.6	72.6	68.3	65.0	16.61	12.61	10.15	8.48	18.80	10.80	15.10	18.40
76	Hughes 530F	83.9	83.4		76.6		65.0	23.59	18.13	14.68	12.32	NA	7.30	NA	18.90
77	BO-105	81.1	79.1	66.5	74.5	68.6	67.0	35.69	28.31	23.32	19.76	14.60	6.60	12.50	14.10
78	Dauphin	85.6	85.9					19.12	14.57	11.75	9.83	NA	NA	NA	NA
79	Bell 206-L	80.4	80.8		73.0	70.0	67.0	23.75	18.26	14.79	12.41	NA	7.40	10.40	13.40
80	Bell 222	89.4	88.1					NA	NA	NA	NA	NA	NA	NA	NA
81	Bell 206-B	81.8	80.4		69.8	67.3	63.0	23.19	17.81	14.41	12.09	NA	12.00	14.50	18.80
82	Agusta 109A	81.7	79.6			69.9	65.0	NA	NA	NA	NA	NA	NA	11.80	14.70
83	Hughes 500E	82.2	81.5			66.5	65.0	19.63	14.98	12.08	10.11	NA	NA	15.70	17.20
84	Enstrom 28F	80.4	77.1			66.0	64.0	NA	NA	NA	NA	NA	NA	14.40	16.40
85	BK-117	79.7	78.8			67.0	64.0	30.11	23.51	19.19	16.17	NA	NA	12.70	13.70
86	Twin Star	80.8	79.6				66.0	26.79	20.74	16.86	14.17	NA	NA	NA	14.80
87	A-Star	78.4	79.2			69.0	66.0	31.17	24.41	19.95	16.83	NA	NA	9.40	12.40
88	Enstrom 280-FX	81.6	81.4			64.0	67.0	NA	NA	NA	NA	NA	NA	17.60	14.60

NOTE Site 1 is the primary centerline site 1325 ft from the helipad
Site 2 is on the centerline 1525 ft from the helipad
Site 3 is a sideline site 600 ft south of site 1
Site 4 is a sideline site 800 ft south of site 1
Site 5 is a sideline site 1000 ft south of site 1
Site 6 is a sideline site 1200 ft south of site 1

Blanks are lost data due equipment malfunction, contamination, etc

the centerline position. Consequently, the altitude and slant distances could not be determined, but of greater importance, the noise associated with the passage of the helicopter would be inconsistent with the other events, since it would be a sideline measurment at the centerline site.

As stated early, the measurement of helicopter operations during the HAI Convention were targets of opportunity, thus the success of the noise monitoring program was contingent on the cooperation of the helicopter pilots since their principle mission was to demonstrate the helicopter's capabilities and features to perspective customers. Therefore, for those events where the helicopter did not fly over the centerline position and altitude was not obtained, a meaningful relationship of L(max) associated with each helicopter was not obtained. Table 2 is a compilation of those events where altitude, slant range, and L(max) were obtained at more than one station. The data recovery was 60, 64, 38, 46, 40, and 53 percent, for sites 1,2,3,4,5, and 6 respectively. Even though there were some stations which lost a reading due to jet noise contamination, comparisons can still be made with respect to the slant range and other events. Table 3 is a compilation of those events where the altitude of the helicopter was obtained

TABLE 2 Helicopter Noise Levels Measured At McCarran During Departures With At Least Two Sites Reporting A Lmax January 19, 1984

Helicopter	Altitude Centerline (ft)	Slant Range for Noise Monitoring Stations (ft)				Lmax (dBA) Station Locations					
						1	2	3	4	5	6
A-Star	163	622	816	1013	1211	81.1	87.0	72.7	70.0	66.5	65.0
A-Star	208	635	827	1021	1218	82.2	80.9	69.9	68.0		62.0
A-Star	203	633	825	1020	1217	80.5	80.8		70.0		67.0
A-Star	343	701	879	1064	1254	78.4	79.2			69.0	66.0
AVERAGE						80.6	82.0	71.3	69.3	67.8	65.0
Agusta 109A	230	643	832	1026	1222	85.8	87.4	80.0		73.7	71.0
BK-117	174	625	819	1015	1213	84.0	84.4				70.0
BK-117	181	627	820	1014	1214	83.1	82.5	71.6	69.7	66.0	65.0
BK-117	218	638	829	1023	1220	83.3	80.4	72.2	73.0	69.1	68.0
BK-117	301	671	855	1044	1237	79.9	78.6		72.7		67.0
BK-117	348	694	872	1059	1249	79.7	78.8			67.0	66.0
AVERAGE						82.0	80.9	71.9	71.8	67.4	67.2
BO-105	438	743	912	1092	1277	80.8	79.5	70.6	68.0	65.6	65.0
BO-105	296	669	853	1043	1236		82.5				
BO-105	183	627	821	1017	1214	84.1	83.4	74.2	73.8	69.0	67.0
BO-105	431	739	909	1089	1275	81.1	79.1	66.5	74.5	68.6	67.0
AVERAGE						82.0	81.1	70.4	72.1	67.7	66.3
Bell 206-B	158	620	815	1012	1210	84.0	82.4	71.8	69.7		68.0
Bell 206-B	284	664	849	1040	1233	79.0	79.3	71.8	70.9	67.0	65.0
Bell 206-B	174	625	819	1015	1213		89.1				
Bell 206-B	262	655	842	1034	1228	80.1	80.1	63.3	69.6	66.8	
Bell 206-B	257	653	840	1032	1227	81.8	80.4		69.8	67.3	63.0
AVERAGE						81.2	82.3	69.0	70.0	67.0	65.3
Bell 206-L	353	696	874	1060	1251	77.6	77.5	74.1		68.9	66.0
Bell 206-L	197	632	824	1019	1216	82.9	82.4	74.0	72.7		66.0
Bell 206-L	264	656	842	1034	1229	81.1	80.1	72.4	73.4	66.2	69.0
Bell 206-L	206	634	826	1021	1218	81.7	80.8	72.9	72.0		
Bell 206-L	403	723	896	1078	1266		78.7		74.0		66.0
Bell 206-L	264	656	842	1034	1229	80.4	80.8		73.0	70.0	67.0
AVERAGE						80.7	80.1	73.4	73.0	68.4	66.8
Bell 222	260	654	841	1033	1228	81.3	84.4				
Bell 222	292	667	852	1042	1235	84.1	83.6	73.8			71.0
Bell 222	312	676	859	1048	1240	84.6	83.4	73.6	74.2		
AVERAGE						83.3	84.5	73.7	74.2		71.0
Bell 412	259	654	841	1033	1228	87.7	89.2	78.7	78.7	75.0	72.0

TABLE 2 (Cont')

Helicopter	Altitude Centerline (ft)	Slant Range for Noise Monitoring Stations (ft)				Lmax (dBA) Station Locations 1	2	3	4	5	6
Bell 47	195	631	823	1019	1216	78.0	78.7		67.7	66.0	63.0
Dauphin	216	638	829	1023	1219	84.8	84.4	74.4	74.1	69.0	70.0
Dauphin	164	622	817	1013	1211	89.4	90.3	75.8	73.5	69.9	68.0
Dauphin	208	635	827	1021	1218	85.6	85.9				
AVERAGE						86.6	86.9	74.1	73.8	69.5	69.0
Enstrom 280 F	282	663	848	1039	1233	79.6	78.7	74.8	73.1	69.3	70.0
Enstrom 280 FX	286	665	850	1040	1234	82.2	81.5	72.0	69.2		68.0
AVERAGE						80.9	80.1	74.0	71.2	69.3	69.0
Hughes 500C	364	702	879	1044	1254	82.2	82.8	75.5	73.4	71.6	71.0
Hughes 500D	295	649	853	1043	1236		89.2				
Hughes 500D	298	670	854	1043	1236	80.8	81.2		72.0		67.0
Hughes 500D	299	670	854	1044	1237	81.4	81.9	74.4	72.1	68.0	67.0
Hughes 500D	361	700	878	1063	1253	79.5	78.9		72.0	69.0	66.0
AVERAGE						80.6	82.8	74.4	72.0	68.5	66.7
Hughes 500E	220	639	830	1024	1220	81.5	82.5	71.2	68.0	63.7	61.2
Hughes 500E	240	646	835	1028	1224	82.7	86.6				
Hughes 500E	276	660	844	1037	1231	80.0	79.0	71.3	69.1	64.4	63.0
Hughes 500E	216	638	829	1023	1219		83.5				
Hughes 500E	272	659	845	1036	1230	80.3	80.2	71.9	71.1	66.3	67.0
Hughes 500E	280	662	848	1038	1232	79.7	78.5	71.2	69.7	65.8	64.0
Hughes 500E	204	634	826	1021	1217	82.2		72.1	71.0	65.0	64.0
Hughes 500E	246	648	837	1030	1225	80.5	80.3	64.2	70.3	67.5	65.0
Hughes 500E	214	637	828	1023	1219	82.2	81.5			66.5	65.0
AVERAGE						81.1	81.5	70.3	69.9	65.4	64.2
Hughes 530F	351	695	874	1040	1250	83.2	82.6		71.8	68.4	65.0
Hughes 530F	311	676	858	1047	1240	79.9	79.0	73.1	70.8	67.8	65.0
Hughes 530F	276	660	844	1037	1231	82.2	78.2			71.0	
Hughes 530F	262	655	842	1034	1226	83.9	83.4		76.6		65.0
AVERAGE						82.3	80.8	73.1	73.1	69.1	65.0
Twin Star	188	629	822	1018	1215	84.1	85.2				67.0
Twin Star	376	708	884	1048	1250	80.3	80.5	71.4	70.1	64.0	65.0
Twin Star	464	758	925	1102	1287	79.7	79.2	70.5	69.0	67.0	65.0
Twin Star	179	626	820	1014	1213	83.4	81.8	64.4	72.6	68.3	65.0
Twin Star	303	672	855	1045	1238	80.8	79.6				66.0
AVERAGE						81.7	81.3	68.8	70.6	66.4	65.6

NOTE Site 1 is primary centerline site 1325 ft from the helipad
Site 2 is on the centerline 1525 ft from the center of the helipad
Site 3 is a sideline site 400 ft. south of site 1
Site 4 is a sideline site 800 ft. south of site 1
Site 5 is a sideline site 1000 ft. south of site 1
Site 6 is a sideline site 1200 ft. south of site 1

Blanks are lost data due to equipment malfunction, contamination, etc

TABLE 3 **Helicopter Noise Levels Measued At McCarran During Departures**

For All Sites Reporting An Lmax January 19, 1984

(Altitude, Slant Range, Lmax)

Event Number	Helicopter	Centerline Altitude (ft)	Slant Range for Noise Monitoring Stations (ft)				Lmax (dBA) for Each Site Location					
			3	4	5	6	1	2	3	4	5	6
3	A-STAR	163	622	816	1013	1211	81.1	87.0	72.7	70.0	67.0	65.0
12	BK-117	181	627	820	1014	1214	83.1	82.5	71.6	69.7	66.0	65.0
28	BK-117	218	638	829	1023	1220	83.3	80.4	72.2	73.0	69.1	68.0
19	BO-105	438	743	912	1092	1277	80.8	79.5	70.6	68.0	65.6	65.0
41	BO-105	183	627	821	1017	1214	84.1	83.4	74.2	73.8	69.0	67.0
77	BO-105	431	739	909	1089	1275	81.1	79.1	66.5	74.5	68.6	67.0
52	Bell 206-B	284	664	849	1040	1233	79.0	79.3	71.8	70.9	67.0	65.0
24	Bell 206-L	264	656	842	1034	1229	81.1	80.1	72.4	73.4	68.0	69.0
53	Bell 412	259	654	841	1033	1228	87.7	89.2	78.7	78.7	75.0	72.0
34	Dauphin	216	638	829	1023	1219	84.8	84.4	76.4	74.1	69.0	70.0
42	Dauphin	164	622	817	1013	1211	89.4	90.3	75.8	73.5	69.9	68.0
31	Enstrom 280 F	282	663	848	1039	1233	79.6	78.7	76.0	73.1	69.3	70.0
23	Hughes 500 C	364	702	879	1064	1254	82.2	82.8	75.5	73.4	71.6	71.0
51	Hughes 500 D	299	670	854	1044	1237	81.4	81.9	74.4	72.1	68.0	67.0
11	Hughes 500 E	220	639	830	1024	1220	81.5	82.5	71.2	68.0	63.7	61.2
20	Hughes 500 E	276	660	846	1037	1231	80.0	79.0	71.3	69.1	64.4	63.0
33	Hughes 500 E	272	659	845	1036	1230	80.3	80.2	71.9	71.1	66.3	67.0
46	Hughes 500 E	280	662	848	1038	1232	79.7	78.5	71.2	69.7	65.8	64.0
73	Hughes 500 E	246	648	837	1030	1225	80.5	80.3	64.2	70.3	67.5	65.0
36	Hughes 530 F	311	676	858	1047	1240	79.7	79.0	73.1	70.8	67.8	65.0
48	Twin Star	376	708	884	1068	1258	80.3	80.5	71.4	70.1	64.0	65.0
64	Twin Star	464	758	925	1102	1287	79.7	79.2	70.5	69.0	67.0	65.0
75	Twin Star	179	626	820	1016	1213	83.4	81.8	64.6	72.6	68.0	65.0
	Average	277.0	665.3	850.4	1040.9	1234.3	81.9	81.7	72.1	71.7	67.7	66.5
	Maximum	464.0	758.5	924.8	1102.4	1286.6	89.4	90.3	78.7	78.7	75.0	72.0
	Minimum	163.0	621.7	816.4	1013.2	1211.0	79.0	78.5	64.2	68.0	63.7	61.2
	Count	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0

NOTE Site number 1 is the centerline site

TABLE 3a **Helicopter Noise Measured At McCarran During Departures**

For All Sites Reporting An Lmax January 19, 1984

(Lmax, Elevation Angle, Delta Lmax)

Event Number	Helicopter	Lmax (dBA) for Each Site Location						Elevation Angle for Each Site				Difference between Centerline and Sideline Site (dBA)			
		1	2	3	4	5	6	3	4	5	6	1-3	1-4	1-5	1-6
[illegible]	A-STAR	81.1	87.0	72.7	70.0	67.0	65.0	15.2	11.5	9.3	7.7	8.4	11.1	14.1	16.1
12	BK-117	83.1	82.5	71.6	69.7	66.0	65.0	14.8	12.7	10.3	8.6	11.5	13.4	17.1	18.1
28	BK-117	83.3	80.4	72.2	73.0	69.1	68.0	20.0	15.2	12.3	10.3	11.1	10.3	14.2	15.3
19	BO-105	80.8	79.5	70.6	68.0	65.6	65.0	36.1	28.7	23.7	20.1	10.2	12.8	15.2	15.8
[illegible]	BO-105	84.1	83.4	74.2	73.8	69.0	67.0	17.0	12.9	10.4	8.7	9.9	10.3	15.1	17.1
[illegible]	BO-105	81.1	79.1	66.5	74.5	68.6	67.0	35.7	28.3	23.3	19.8	14.6	6.6	12.5	14.1
[illegible]	Bell 206-B	79.0	79.3	71.8	70.9	67.0	65.0	25.3	19.5	15.9	13.3	7.2	8.1	12.0	14.0
[illegible]	Bell 206-L	81.1	80.1	72.4	73.4	68.0	69.0	23.7	18.3	14.8	12.4	8.7	7.7	13.1	12.1
53	Bell 412	87.7	89.2	78.7	78.7	75.0	72.0	23.3	17.9	14.5	12.2	9.0	9.0	12.7	15.7
34	Dauphin	84.8	84.4	76.4	74.1	69.0	70.0	19.8	15.1	12.2	10.2	8.4	10.7	15.8	14.8
42	Dauphin	89.4	90.3	75.8	73.5	69.9	68.0	15.3	11.6	9.3	7.8	13.6	15.9	19.5	21.4
31	Enstrom 280 F	79.6	78.7	76.0	73.1	69.3	70.0	25.2	19.4	15.7	13.2	3.6	6.5	10.3	9.6
[illegible]	Hughes 500 C	82.2	82.8	75.5	73.4	71.6	71.0	31.2	24.5	20.0	16.9	6.7	8.8	10.6	11.2
[illegible]	Hughes 500 D	81.4	81.9	74.4	72.1	68.0	67.0	26.5	20.5	16.6	14.0	7.0	9.3	13.4	14.4
[illegible]	Hughes 500 E	81.5	82.5	71.2	68.0	63.7	61.2	20.1	15.4	12.4	10.4	10.3	13.5	17.8	20.3
20	Hughes 500 E	80.0	79.0	71.3	69.1	64.4	63.0	24.7	19.0	15.4	13.0	8.7	10.9	15.6	17.0
33	Hughes 500 E	80.3	80.2	71.9	71.1	66.3	67.0	24.4	18.8	15.2	12.8	8.4	9.2	14.0	13.3
46	Hughes 500 E	79.7	78.5	71.2	69.7	65.8	64.0	25.0	19.3	15.6	13.1	8.5	10.0	13.9	15.7
73	Hughes 500 E	80.5	80.3	64.2	70.3	67.5	65.0	22.3	17.1	13.8	11.6	16.3	10.2	13.0	15.5
[illegible]	Hughes 530 F	79.7	79.0	73.1	70.8	67.8	65.0	27.4	21.2	17.3	14.5	6.6	8.9	11.9	14.7
68	Twin Star	80.3	80.5	71.4	70.1	64.0	65.0	32.1	25.2	20.6	17.4	8.9	10.2	14.3	15.3
[illegible]	Twin Star	79.7	79.2	70.5	69.0	67.0	65.0	37.7	30.1	24.9	21.1	9.2	10.7	12.7	14.7
75	Twin Star	83.4	81.8	64.6	72.6	68.0	65.0	16.6	12.6	10.1	8.5	18.8	10.8	15.4	18.4
	Average	81.9	81.7	72.1	71.7	67.7	66.5	24.4	18.9	15.4	12.9	9.8	10.2	14.2	15.4
	Maximum	89.4	90.3	78.7	78.7	75.0	72.0	37.7	30.1	24.9	21.1	18.8	15.9	19.5	21.4
	Minimum	79.0	78.5	64.2	68.0	63.7	61.2	15.2	11.5	9.3	7.7	3.6	6.5	10.3	9.6
	Count	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0

NOTE Site number 1 is the centerline site

and all of the sites were able to measure an uncontaminated L(max) reading. Of the 89 events recorded, there were only 23 events (26% data recovery) with a complete record (e.g. no contamination at all sites and altitude was determined). Initially, it would seem that the data recovery was low, however, a recovery of 26% is not unreasonable considering the elements that had to be dealt with, volunteer cooperation from each pilot and persistent contamination of events from routine air carrier operations off of runway 07-25.

For those events where there was a complete record, the average L(max) at the primary centerline position was 81.9 dB(A), the maximum was 89.4 dB(A) and the minimum was 79.0 dB(A).

The secondary centerline position which was 200 feet further west, indicated similar values except the L(max) was at times slightly higher. After the helicopters passed site 2 they began their turn to the north to fly to the demonstration area. At times there were operations where the pilot initiated his turn between the primary site and site 2. This might account for some of the higher readings observed at site 2 when the values are compared.

The highest recorded L(max) as presented in Table 3 was 89.4 dB(A) associated with the Dauphin which passed over the primary centerline site at an altitude of 164 feet. This L(max) was slightly exceeded at the secondary site with a L(max) reading of 90.3 dB(A). In examining the noise levels for all the events by helicopter model, there tends to be a repeatability in the L(max) values as recorded at the primary centerline site (Table 2). Remembering that these events are targets of opportunity, the variations in L(max) values are not without expectation, since the flight path would change for each pass, the load factor would change, angle of climb may vary, speed of climb may vary, point of turning would be different for each helicopter, a different pilot may be operating the aircraft, etc. Even with these variations, which can all directly effect the level of noise associated with each helicopter as it passes the primary site, there was a tendency for the L(max) to vary by $\pm$3 dB(A) for each helicopter model.

The Hughes 500-E is a good example of this variation in L(max) readings. There were 11 events for the 500-E. The altitude varied from 204 to 280 feet. There were two events for which the

altitude could not be determined, since the aircraft turned before passing over the primary site leaving then 9 events (Table 2). The L(max) values as recorded ranged from 79.7 (associated with an early turn) to 82.7 dB(A). In general, the L(max) values tend to center around 80-82 dB(A).

On the other hand, it is extremely difficult to obtain a perspective of the L(max) readings for the Agusta 109A. Even though the L(max) values were recorded at most of the sites for the 109A, there was no altitude data, since the Agusta always turned *before reaching* the primary site (Table 1). Even with the 109A turning early, the L(max) values tended to be higher than the other helicopters which passed directly over the primary site.

Figures 4 to 10 show the L(max) value vs distance for some of the helicopter events. Viewing of these graphs indicates that the L(max) values decreased at an approximate rate of 6 dB(A) per doubling of distance.

Data for SEL are not being reported since the majority of the data were contaminated by the air carrier operations off runway 07-25.

FIGURE 4

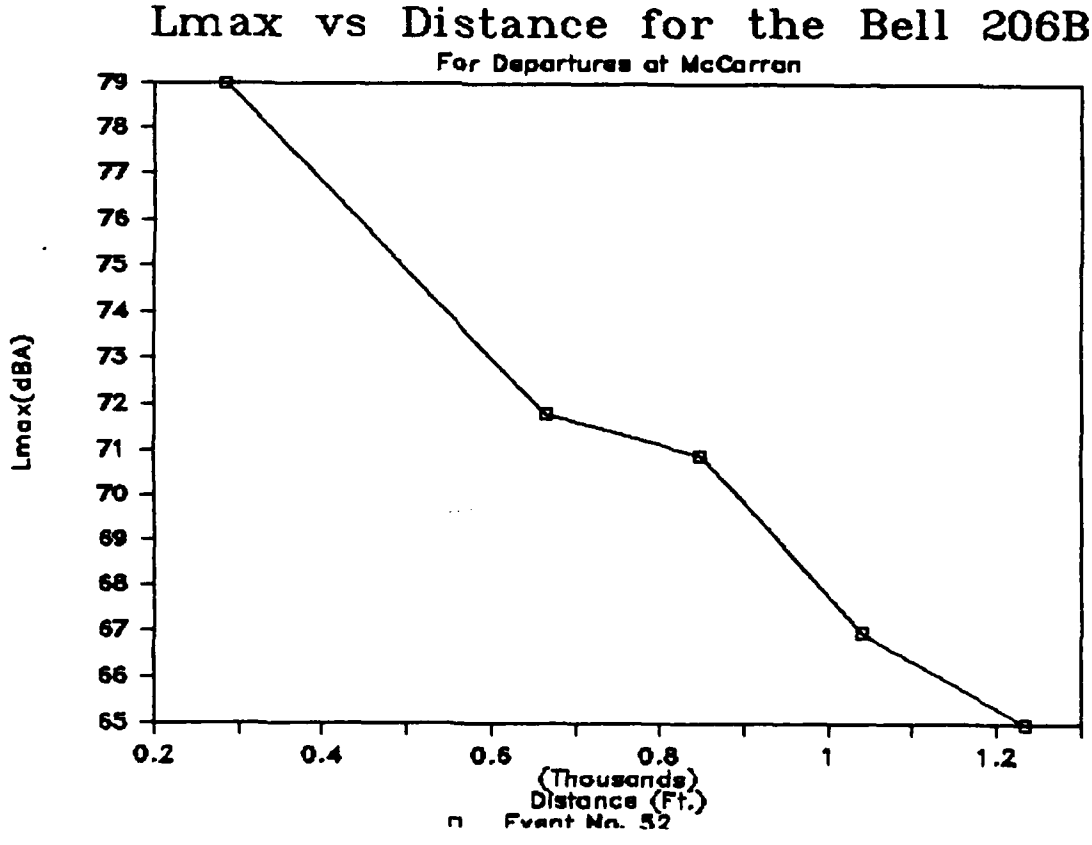

Lmax vs Distance for the Bell 206B
For Departures at McCarran
Lmax(dBA)
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
0.2
0.4
0.6
0.8
1
1.2
(Thousands)
Distance (Ft.)
Event No. 52

FIGURE 5

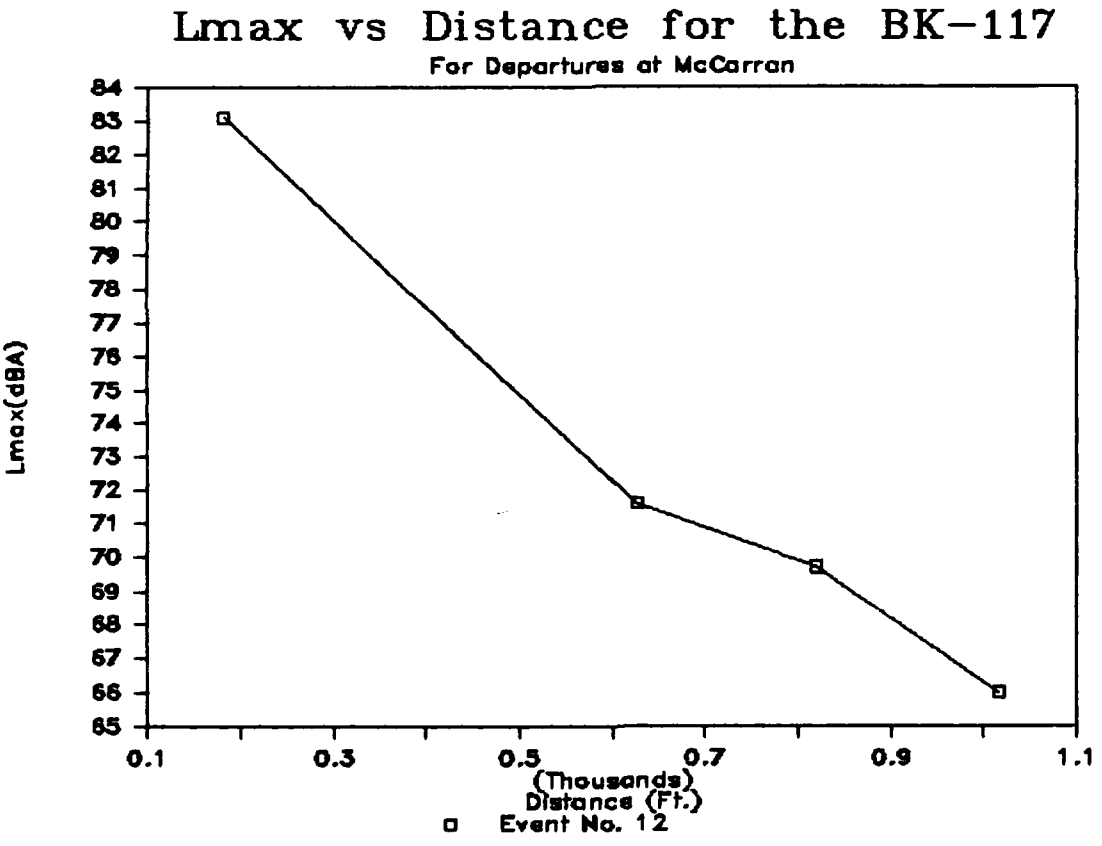

Lmax vs Distance for the BK-117
For Departures at McCarran
Lmax(dBA)
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
0.1
0.3
0.5
0.7
0.9
1.1
(Thousands)
Distance (Ft.)
Event No. 12

FIGURE 6

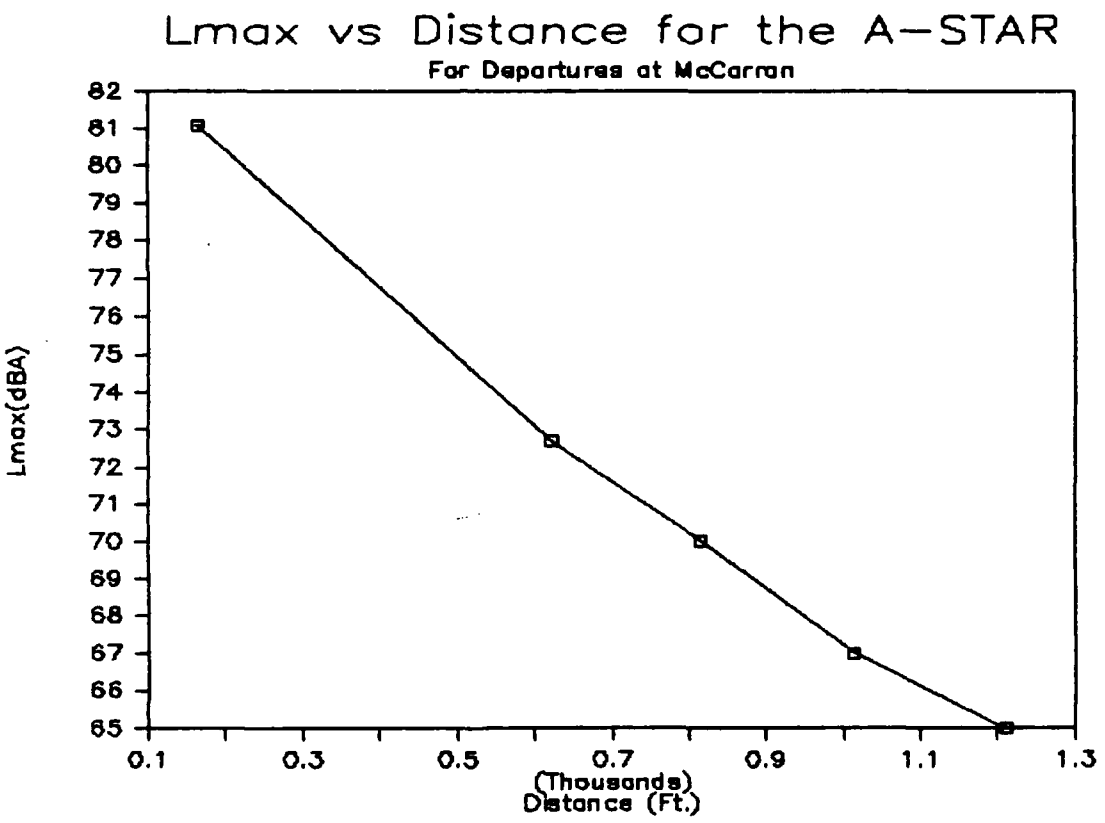

Lmax vs Distance for the A-STAR
For Departures at McCarran
Lmax(dBA)
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
0.1
0.3
0.5
0.7
0.9
1.1
1.3
(Thousands)
Distance (Ft.)

FIGURE 7

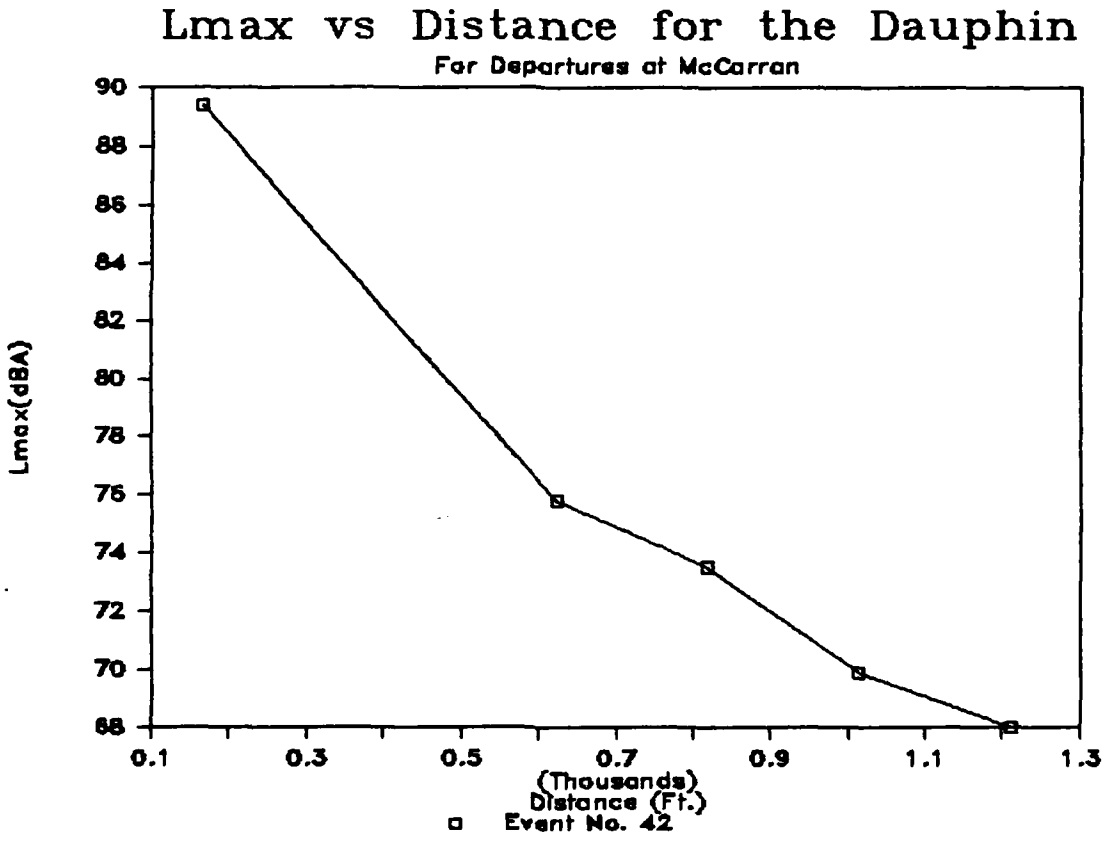

Lmax vs Distance for the Dauphin
For Departures at McCarran
Lmax(dBA)
90
88
86
84
82
80
78
76
74
72
70
68
0.1
0.3
0.5
0.7
0.9
1.1
1.3
(Thousands)
Distance (Ft.)
Event No. 42

FIGURE 8

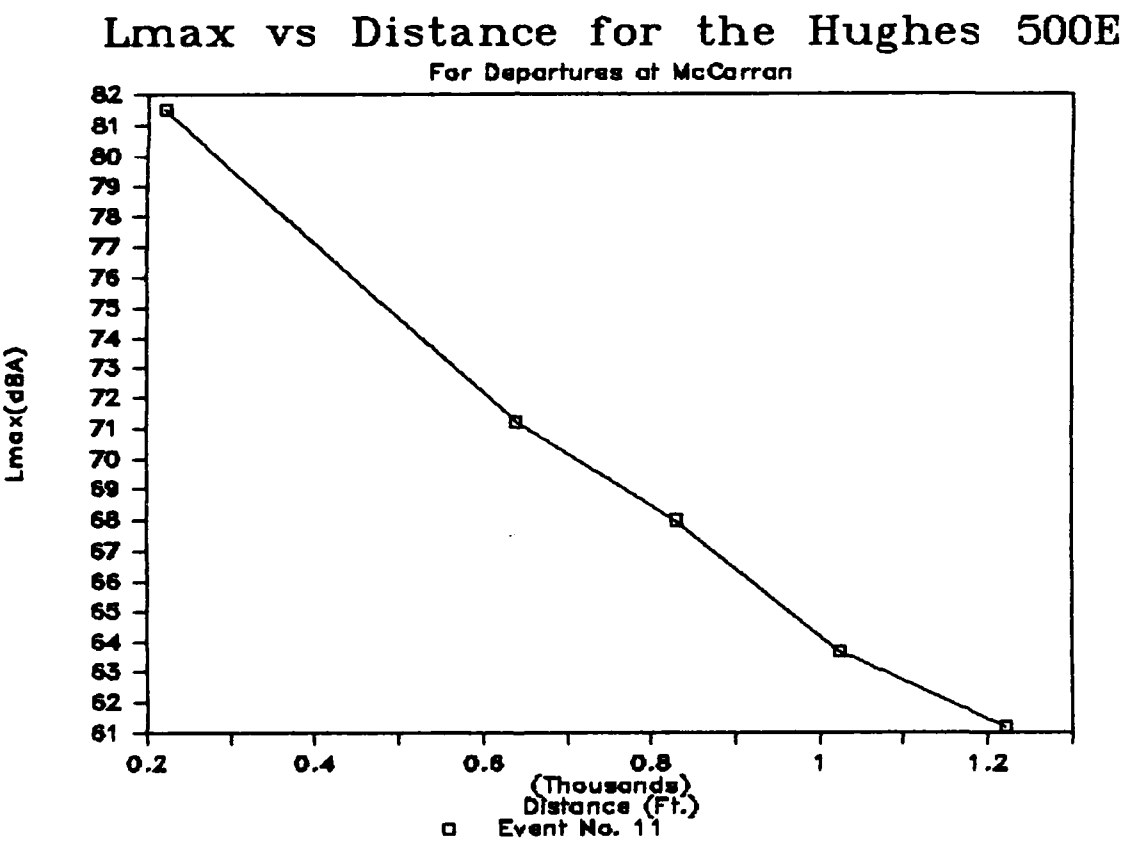

Lmax vs Distance for the Hughes 500E
For Departures at McCarran
Lmax(dBA)
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
0.2
0.4
0.6
0.8
1
1.2
(Thousands)
Distance (Ft.)
Event No. 11

FIGURE 9

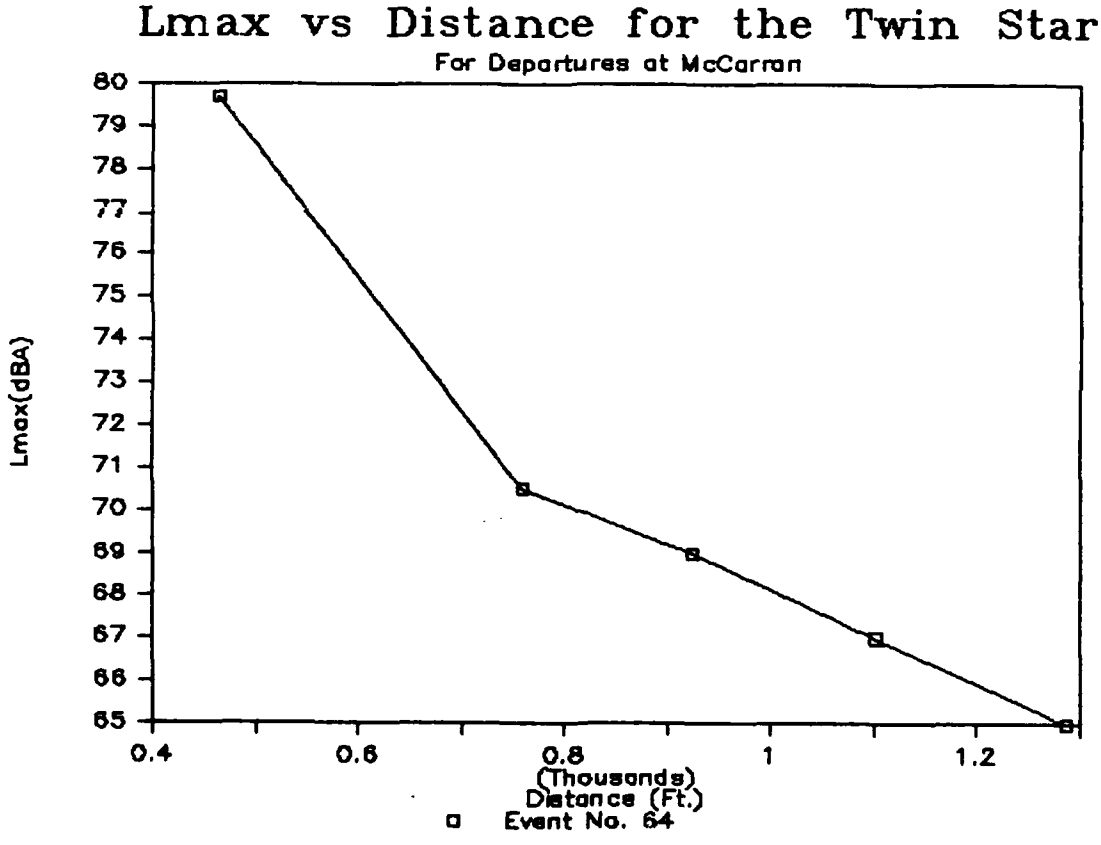
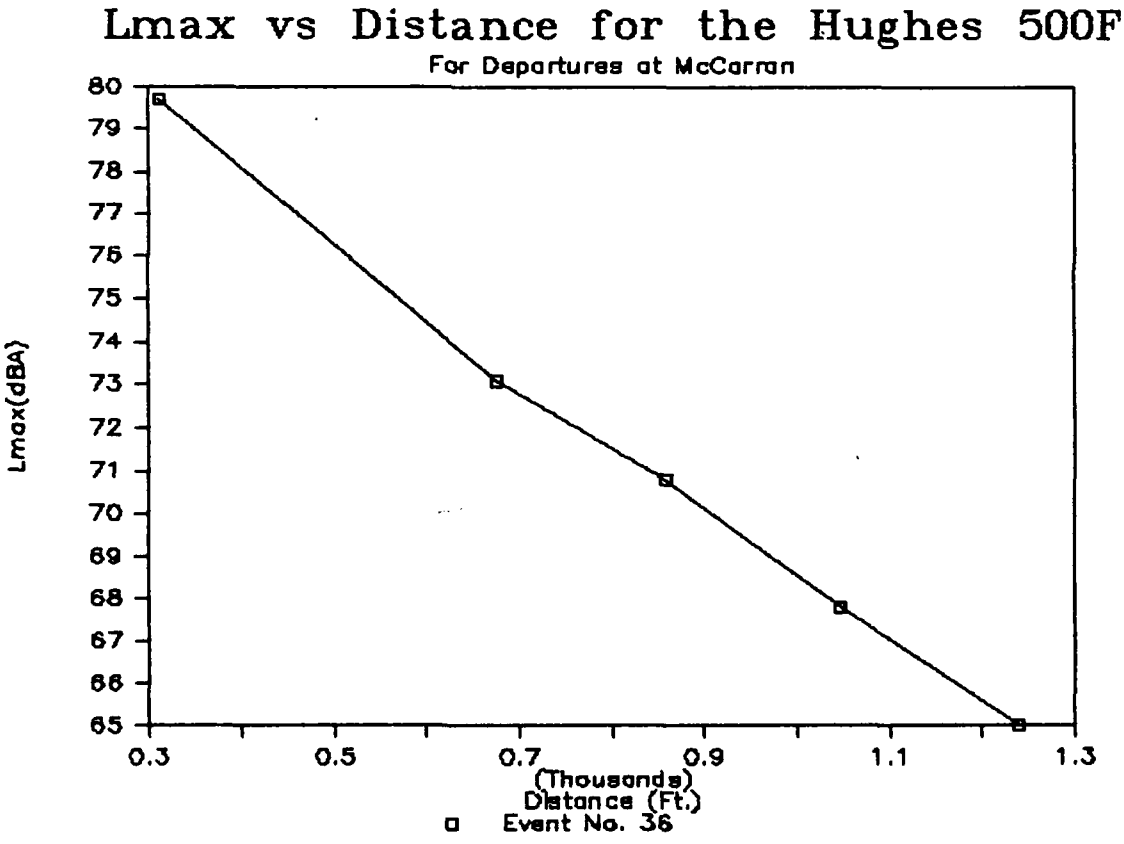

Lmax vs Distance for the Twin Star
For Departures at McCarran
Lmax(dBA)
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
0.4
0.6
0.8
1
1.2
(Thousands)
Distance (Ft.)
Event No. 64

FIGURE 10


Lmax vs Distance for the Hughes 500F
For Departures at McCarran
Lmax(dBA)
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
0.3
0.5
0.7
0.9
1.1
1.3
(Thousands)
Distance (Ft.)
Event No. 36

6.2 McCarran Approaches

Noise levels associated with arrivals were monitored on January 21, 1984, at McCarran International Airport. There were a total of 69 events which were comprised of 14 different helicopter models. Due to the physical constraints imposed in locating the monitoring sites with respect to the approach path, not all of the helicopters passed directly over the established centerline site. There were 27 events in which the helicopter passed within a reasonable distance of the primary centerline site. Table 4 presents the L(max) values for each event, the altitude over the priamry centerline site and the slant range. Table 4a is a continuation of Table 4 with L(max), elevation angle, and the difference in dB(A) between the centerline and sideline sites.

The maximum recorded L(max) value of 95.0 dB(A) during approaches was associated with a BO-105 which passed over the primary site at an altitude of 62 feet. The minimum L(max) value of 84.2 dB(A) was associated with the A-Star which passed over the primary centerline site at an altitude of 179 feet. The average L(max) at the primary centerline site for all the events was 88.6 dB(A). Variations in the L(max) values for each helicopter

TABLE 4 **Helicopter Noise Measurements During Arrivals At McCarran**

For Events Where The Helicopter Passed Over Centerline

(Altitude, Slant Range, Lmax)

Event Number	Helicopter	Centerline Altitude (ft)	Slant Range for Monitoring Stations (ft)			Lmax (dBA) for Each Site Location				
			1	3	4	1	2	3	4	5
07	A-Star	179	205	205	268	83.0	84.2	85.9	84.0	87.5
18	A-Star	187	212	212	274	84.0	87.8	89.1	87.0	88.4
33	A-Star	107	146	146	227	83.0	88.4	88.4	85.0	95.2
45	A-Star	106	146	146	226	NA	84.7	84.3	81.0	88.6
17	BK-117	85	131	131	217	90.5	89.9	86.0	83.0	87.8
24	BO-105	180	206	206	269	92.0	91.1	NA	88.0	88.3
32	BO-105	62	118	118	209	87.5	95.0	94.2	87.0	94.3
58	BO-105	161	190	190	257	90.0	85.1	82.2	79.0	84.4
52	Bell 206-B	224	245	245	300	83.0	84.7	82.9	80.0	87.1
10	Bell 206-L	117	154	154	232	86.0	88.0	87.8	83.0	91.4
25	Bell 206-L	114	152	152	230	87.5	92.5	87.4	80.0	94.2
36	Bell 206-L	134	167	167	241	85.5	86.1	90.3	84.0	92.7
13	Bell 222	353	367	367	406	84.5	84.6	81.9	78.0	86.8
49	Bell 222	144	192	192	259	87.0	89.3	87.0	83.0	89.1
11	Bell 412	273	291	291	338	92.0	88.9	86.7	85.0	89.7
23	Bell 412	236	256	256	309	92.5	88.7	85.5	NA	89.7
55	Bell 412	167	195	195	261	90.5	89.9	90.5	84.0	92.5
01	Dauphin	223	244	244	300	92.0	91.0	88.4	82.0	92.0
03	Hughes 500D	127	162	162	237	91.5	90.0	83.6	79.0	92.0
16	Hughes 500D	103	144	144	225	87.0	88.1	NA	82.0	93.3
21	Hughes 500D	99	141	141	223	90.0	92.2	NA	82.0	91.7
68	Hughes 500E	264	282	282	331	89.0	90.2	86.8	NA	92.5
08	Hughes 530F	234	254	254	308	86.0	86.6	84.5	81.0	77.7
39	Hughes 530F	204	227	227	286	84.0	87.7	91.3	82.0	87.9
59	Hughes 530F	204	227	227	286	86.0	87.3	85.8	82.0	87.7
41	Twin Star	192	216	216	277	NA	91.3	97.2	88.0	94.4
56	Twin Star	205	228	228	286	86.0	87.6	87.5	86.0	87.7
	Minumum	62	118	118	209	83.0	84.2	81.9	78.0	77.7
	Maximum	353	367	367	406	92.5	95.0	97.2	88.0	95.2
	Average	174	204	204	270	87.7	88.6	87.3	83.0	89.8
	Count	27	27	27	27	25.0	27.0	24.0	25.0	27.0

NOTE. Site 2 is the Centerline Location and NA are data not available
Site 1 is a sideline site 100 ft. to the west of site 2
Site 3 is a sideline site 100 ft. to the east of site 2
Site 4 is a sideline site 200 ft. to the east of site 2
Site 5 is on the centerline 200 ft to the south of site 2

TABLE 4a **Helicopter Noise Measurements During Arrivals At McCarran For Events Where The Helicopter Passed Over Centerline (Lmax, Elevation Angle, Delta Lmax)**

Event Number	Helicopter	Lmax (dBA) for Each Site Location					Elevation Angle for Each Site			Difference between Centerline and Sideline Site (dBA)		
		1	2	3	4	5	1	3	4	2-1	2-3	2-4
07	A-Star	83.0	84.2	85.9	84.0	87.5	60.8	60.8	41.8	1.2	-1.7	0.2
18	A-Star	84.0	87.8	89.1	87.0	88.4	61.9	61.9	43.1	3.8	-1.3	0.8
33	A-Star	83.0	88.4	88.4	85.0	95.2	46.9	46.9	28.1	5.4	0.0	3.4
45	A-Star	NA	84.7	84.3	81.0	88.6	46.7	46.7	27.9	NA	0.4	3.7
17	BK-117	90.5	89.9	86.0	83.0	87.8	40.4	40.4	23.0	-0.6	3.9	6.9
24	BO-105	92.0	91.1	NA	88.0	88.3	60.9	60.9	42.0	-0.9	NA	3.1
32	BO-105	87.5	95.0	94.2	87.0	94.3	31.8	31.8	17.2	7.5	0.8	8.0
58	BO-105	90.0	85.1	82.2	79.0	84.4	58.2	58.2	38.8	-4.9	2.9	6.1
52	Bell 206-B	83.0	84.7	82.9	80.0	87.1	65.9	65.9	48.2	1.7	1.8	4.7
10	Bell 206-L	86.0	88.0	87.8	83.0	91.4	49.5	49.5	30.3	2.0	0.2	5.0
25	Bell 206-L	87.5	92.5	87.4	80.0	94.2	48.7	48.7	29.7	5.0	5.1	12.5
36	Bell 206-L	85.5	86.1	90.3	84.0	92.7	53.3	53.3	33.8	NA	-4.2	2.1
13	Bell 222	84.5	84.6	81.9	78.0	86.8	74.2	74.2	60.5	0.1	2.7	6.6
49	Bell 222	87.0	89.3	87.0	83.0	89.1	58.6	58.6	39.4	2.3	2.3	6.3
11	Bell 412	92.0	88.9	86.7	85.0	89.7	69.9	69.9	53.8	-3.1	2.2	3.9
23	Bell 412	92.5	88.7	85.5	NA	89.7	67.0	67.0	49.7	-3.8	3.2	
55	Bell 412	90.5	89.9	90.5	84.0	92.5	59.1	59.1	39.9	-0.6	-0.6	5.9
01	Dauphin	92.0	91.0	88.4	82.0	92.0	65.8	65.8	48.1	-1.0	2.6	9.0
03	Hughes 500D	91.5	90.0	83.6	79.0	92.0	51.8	51.8	32.4	-1.5	6.4	11.0
16	Hughes 500D	87.0	88.1	NA	82.0	93.3	45.8	45.8	27.2	1.1	NA	6.1
21	Hughes 500D	90.0	92.2	NA	82.0	91.7	44.7	44.7	26.3	2.2	NA	10.2
68	Hughes 500E	89.0	90.2	86.8	NA	92.5	69.3	69.3	52.9	1.2	3.4	
08	Hughes 530F	86.0	86.6	84.5	81.0	77.7	66.9	66.9	49.5	0.6	2.1	5.6
39	Hughes 530F	86.0	87.7	91 3	82.0	87.9	63.9	63.9	45.6	1.7	-3.6	5.7
59	Hughes 530F	86.0	87.3	85.8	82.0	87.7	63.9	63.9	45.6	1.3	1.5	5.3
41	Twin Star	NA	91.3	97.2	88.0	94.4	62.5	62.5	43.8	NA	-5.9	3.3
56	Twin Star	86.0	87.6	87.5	86.0	87.7	64.0	64.0	45.7	1.6	0.1	1.6
	Minumum	83.0	84.2	81.9	78.0	77.7	31.8	31.8	17.2	-4.9	-5.9	0.2
	Maximum	92.5	95.0	97.2	88.0	95.2	74.2	74.2	60.5	7.5	6.4	12.5
	Average	87.7	88.6	87.3	83.0	89.8	57.5	57.5	39.4	0.9	1.0	5.5
	Count	25.0	27.0	24.0	25.0	27.0	27.0	27.0	27.0	24.0	24.0	25.0

NOTE: Site 2 is the Centerline Location

Site 1 is a sideline site 100 ft. to the west of site 2
Site 3 is a sideline site 100 ft. to the east of site 2
Site 4 is a sideline site 200 ft. to the east of site 2
Site 5 is on the centerline 200 ft. to the south of site 2

can be attributed to changes in the flight path over the centerline site (e.g. the helicopter might have passed further to the right or left for each subsequent pass), change in load, change in glide slope, change in speed, etc.

A prime example of the variation is the A-Star. There were four approaches in which the A-Star passed within a reasonable distance over the centerline position. For the first two events the A-Star passed by at an altitude of 179 and 187 feet but the L(max) values at the primary site was 84.2 and 87.8 dB(A). On the third and fourth pass the altitude was 107 and 106 feet, however, the L(max) was 88.4 and 84.7 dB(A). In reviewing the Hughes 530-F there was a repeatability in the L(max) values recorded with a consistency in the altitude for each pass over the primary site. Keeping these variation within perspective, the observed L(max) values for all events appears to be in the high 80's dB(A) associated with an altitude range of 62 to 353 feet.

6.3 Convention Center

Noise levels associated with arrivals and departures at the Convention Center were monitored on January 20, 1984. The HAI

had a prototype all-weather type helipad set up at the Convention Center. The helipad clearly showed how versatile the helicopter can be as a mode of transportation in the urban environment. Four noise monitoring sites were deployed to measure the L(max) values during approach, departure, and terminal operations including flat-pitch-idle-running and hover. There were eight events recorded. The helicopters consisted of the Bell 47G, 206-B and 206-L, Aerospatiale Twin Star and Dauphin, and the Hughes 500-D.

Table 5 presents the L(max) and L(eq) values observed from the helicopters that flew into the Convention Center helipad. For the first four events site 3 was not able to record the data due to equipment malfunction. Because of the high volume of traffic on Paradise Rd. the ambient Leq levels as recorded at site 4 exceeded the Leq values during the terminal operations at the helipad. This site was located the fartherest from the helipad; therefore, it is not unexpected that the ambient L(eq) values would be dominated by the local traffic.

The highest L(max) observed from the helicopters of 98.4 dB(A) was associated with the Dauphin during the approach. The minimum

TABLE 6 Noise Levels Measured At The Las Vegas Convention Center

LMAX Values in dBA

Event Number	Helicopter	Approach 1	Approach 2	Approach 3	Approach 4	Flat-pitch-idle (NE) 1	Flat-pitch-idle (NE) 2	Flat-pitch-idle (NE) 3	Flat-pitch-idle (NE) 4	Hover (NE) 1	Hover (NE) 2	Hover (NE) 3	Hover (NE) 4	Hover (SE) 1	Hover (SE) 2	Hover (SE) 3	Hover (SE) 4
1	Bell 47G	92.4	87.5	NA	72.0	73.5	71.8	NA	NA	76.7	70.5	NA	65.5	78.4	73.7	NA	NA
2	Bell 206-B	91.5	92.7	NA	73.5	70.8	64.5	NA	NA	82.9	76.9	NA	68.5	77.1	68.9	NA	69.0
3	Bell 206-L	95.3	93.5	NA	76.0	NA	69.9	NA	62.0	85.7	78.8	NA	67.0	80.5	74.3	NA	64.5
4	Twin Star	96.1	97.0	NA	80.0	84.6	NA	NA	NA	NA	NA	NA	70.0	NA	NA	NA	NA
5	Twin Star	92.9	93.4	NA	79.0	78.7	73.1	NA	69.0	82.7	75.1	NA	70.0	79.3	72.6	NA	72.0
6	Dauphin	98.4	94.4	NA	80.0	83.0	73.8	81.7	71.0	87.4	77.8	82.8	71.5	84.7	76.4	85.8	77.0
7	Bell 206-B	94.3	91.7	80.1	NA	78.2	72.9	71.3	NA	83.1	75.0	74.0	NA	80.5	74.3	76.0	NA
8	Hughes 500D	90.5	83.4	81.4	77.0	81.6	75.8	76.4	NA	81.3	74.4	72.8	69.5	78.7	72.6	78.3	70.0

LEQ Values in dBA

Event Number	Helicopter	Approach 1	Approach 2	Approach 3	Approach 4	Flat-pitch-idle (NE) 1	Flat-pitch-idle (NE) 2	Flat-pitch-idle (NE) 3	Flat-pitch-idle (NE) 4	Hover (NE) 1	Hover (NE) 2	Hover (NE) 3	Hover (NE) 4	Hover (SE) 1	Hover (SE) 2	Hover (SE) 3	Hover (SE) 4
1	Bell 47G	85.7	82.9	NA	NA	72.1	68.1	NA	NA	74.2	69.5	NA	NA	73.1	72.9	NA	NA
2	Bell 206-B	84.5	89.0	NA	NA	69.3	62.5	NA	NA	80.6	75.0	NA	NA	75.3	67.8	NA	NA
3	Bell 206-L	89.2	88.6	NA	NA	70.4	67.0	NA	NA	83.1	75.9	NA	NA	77.9	71.7	NA	NA
4	Twin Star	89.4	90.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Twin Star	87.7	88.4	NA	NA	76.9	70.4	NA	NA	77.2	71.3	NA	NA	76.9	69.3	NA	NA
6	Dauphin	92.8	87.3	NA	NA	80.6	72.1	80.3	NA	84.1	75.0	80.4	NA	81.0	74.1	83.1	NA
7	Bell 206-B	88.9	86.9	75.7	NA	75.8	70.1	69.3	NA	79.0	73.4	72.2	NA	76.3	69.7	73.5	NA
8	Hughes 500D	84.7	78.9	75.3	NA	82.3	74.3	75.7	NA	74.6	71.1	70.1	NA	77.1	71.3	73.2	NA

LMAX Vaues in dBA

Event Number	Helicopter	Flat-pitch-idle (SE) 1	Flat-pitch-idle (SE) 2	Flat-pitch-idle (SE) 3	Flat-pitch-idle (SE) 4	Departure 1	Departure 2	Departure 3	Departure 4
1	Bell 47G	74.4	70.8	NA	NA	NA	NA	NA	NA
2	Bell 206-B	69.0	69.8	NA	NA	86.6	81.9	NA	NA
3	Bell 206-L	74.4	68.5	NA	64.5	91.6	87.2	NA	79.8
4	Twin Star	NA	NA	NA	NA	91.9	88.9	NA	80.0
5	Twin Star	80.2	72.1	NA	69.0	92.7	90.6	NA	80.8
6	Dauphin	81.7	71.3	80.7	70.0	95.1	91.0	85.3	78.0
7	Bell 206-B	76.3	NA	74.1	68.0	92.2	87.2	81.9	74.8
8	Hughes 500D	82.1	70.6	76.5	71.0	90.4	87.0	84.7	79.5

LEQ Values in dBA

Event Number	Helicopter	Flat-pitch-idle (SE) 1	Flat-pitch-idle (SE) 2	Flat-pitch-idle (SE) 3	Flat-pitch-idle (SE) 4	Departure 1	Departure 2	Departure 3	Departure 4
1	Bell 47G	76.6	69.5	NA	NA	NA	NA	NA	NA
2	Bell 206-B	67.8	67.1	NA	NA	83.7	71.1	NA	NA
3	Bell 206-L	72.3	66.8	NA	NA	85.7	82.3	NA	NA
4	Twin Star	NA	NA	NA	NA	87.6	84.4	NA	NA
5	Twin Star	78.6	70.5	NA	NA	86.2	84.7	NA	NA
6	Dauphin	77.6	68.9	78.2	NA	89.6	84.2	79.7	NA
7	Bell 206-B	74.9	68.7	72.6	NA	87.7	81.2	77.6	NA
8	Hughes 500D	80.6	73.0	74.6	NA	85.9	81.9	79.6	NA

Site 1 is on the centerline 304 ft. from the helipad
Site 2 is on the centerline 511 ft. from the helipad
Site 3 is a sideline site 294 ft. west of the helipad
Site 4 is a sideline site 488 ft. northwest of site 2

L(max) value observed during approaches was 72.0 dB(A) for the Bell 47G, Soloy. In comparing the L(max) values for sites 1 and 2 the values are in close agreement. This would be expected since both sites were on the centerline for approach separated only by 200 feet. Differences in the observed values are in part attributed to the glide slope of the helicopter and descent rate used by each helicopter pilot. As to the L(max) values observed during departures, they were comparable to those for approach but were lower by approximately 2 to 5 dB(A). Variations were a function of the individual performance of the helicopter pilot in departing the helipad, including load factors, rate of ascent, and rate of climb over the centerline.

Even though site 4 was the fartherest site of all of the locations and was affected by the ambient noise levels from the local traffic, it was still able to observe a L(max) value for most of the events, including flat-pitch-idle-running and hover. The values, however, were barely above the ambient noise levels.

For the terminal operations, the L(eq) values ranged from the low 70's to the mid 80's dB(A). Each of the four operations had a duration of approximately 20-30 seconds. For events 6,

7, and 8, there was considerable variation in the observed L(eq) values, with site 2 showing the lowest values consistently. This would be expected, since site 2 was 511 feet from the center of the helipad vs 294 feet for site 3. In comparing the values between sites 1 and 3 the L(eq) values were consistently higher at site 1 when the nose of the helicopter was oriented toward the northeast. Part of this may be attributed to the tail rotor and exhaust port pointing directly to site 1, however, when the aircraft rotated to the southeast the differences between the two sites was not as sharp, with the tail rotor and exhaust port oriented more toward site 3, but not necessarily a direct line.

In essence, some directivity in the noise levels were observed, but because these events were targets of opportunity and there were high ambient noise levels from the local traffic, definitive conclusions as to the degree of changes in the L(max) and L(eq) and the exposure can not be concluded from this test program for the Convention Center location.

7.0 Concluding Remark

Table 6 presents typical L(max) values for noise associated with the urban environment. When comparing the observations as presented in this report to those of Table 6 one can easily see that the helicopter is not necessarily that intrusive. One has to be within a relatively close proximity to the helipad to be impacted by the noise as was shown by the lost of data at site 4 at the Convention Center. Even at McCarran International Airport where the ambient noise was relatively low, the noise associated with the helicopter operations was comparatively insignificant to the jet air carriers. However, this is not to say that the noise may not be intrusive, since this term is very qualitative and is a function of personal perception.

TABLE 5

NOISE LEVELS TYPICALLY ENCOUNTERED

IN AN URBAN ENVIRONMENT

Source of Noise	L(max)
Rustling leaves	20
Room in a quiet dwelling at midnight	32
Soft whispers at 5 feet	34
Window air conditioner	55
Conversational speech	60
Busy restaurant	65
Vacuum cleaners in a quiet residence (at 10 ft)	69
Ringing alarm clock (at 2 ft)	80
Heavy city traffic	92
Home lawn mower	98
Banging of steel plate	104
Air hammer	107
Jet airliner (500 feet overhead)	115

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